THE OXFORD GEOGRAPHIES

EDITED BY A. J. HERBERTSON

AN INTRODUCTION TO PLANT GEOGRAPHY

BY

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PREFACE

THE importance of vegetation for the student of geography, and in the teaching of geography, is gradually being recognized. As an indication of the quality of a region it must be taken into account. For instance, the differences between the denser forests of the low-lying swampy lands round equatorial rivers and the opener woods of the better drained higher ground between them are of great importance. In practical affairs the distribution of this or that plant association may often be taken as a guide to the profitable extension of cultivation of this or that crop.

For teaching purposes the study of vegetation is equally important. From descriptions of the different kinds of vegetation it is natural on the one hand to pass to a study of climatic conditions which are associated with them, and on the other to the way in which they have influenced the occupations and mode of life of the peoples who dwell on them. The contrast between the vegetation and climate of the hot wet jungles of the equator and the hot dry scrub lands which border the desert are very striking, and their influence on the life of the people quite as remarkable. In fact vegetation is the link between physical geography and human geography.

So important is this study of vegetation that special wall maps for the world and for each continent have been

prepared on the same projections and scales as those showing physical features and rainfall. (Oxford Wall Maps.[1]) These are so coloured that they can be used either in lower or upper forms, the different colours alone being regarded in the former, the varying shades of those colours in the latter. For the upper forms this introduction to plant geography has been written by Dr. Marcel Hardy, the compiler of the wall maps. It will be followed by a more advanced book.

The author wishes to thank those whose names are given below for the photographs they have been good enough to lend; and Mr. Trevor Haddon for his sketches: Mr. H. M. Lomas, Col. Couchman, Mr. A. W. W. Brown, Mr. J. Lagarde, Mr. C. W. Mathers, Mr. Donaldson Smith, and Miss H. F. M. King. Fig. 1*a* is reproduced from Tansley's *Types of British Vegetation* by permission of Mr. Tansley and the Syndics of the Cambridge University Press.

A. J. HERBERTSON.

[1] Prices (net): unmounted, 7*s.* (Asia, 10*s.* 6*d.*), or £2. 10*s.* for the set of 7 maps; mounted on cloth to fold, 8*s.* 6*d.* (Asia, 12*s.* 6*d.*), or £3 for the set; mounted on cloth and rollers, varnished or unvarnished, 10*s.* 6*d.* (Asia, 15*s.*), or £3. 15*s.* for the set.

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INTRODUCTION

CHAPTER I

DIFFERENT VEGETATIONS IN DIFFERENT SURROUNDINGS

Most of us have some favourite landscape. We like to look at it at all seasons of the year. We are accustomed to its changes from the green leaves of summer to the bare boughs of winter and explain them by the changes of the seasons. But we do not usually ask ourselves the question how it happens that the different woods and meadows come to be where they are. If we have travelled we know that landscapes differ. Let us begin by looking at the vegetation of some of the different kinds of landscape which are found in our own islands.

Exmoor. Let us picture to ourselves Exmoor with its rolling hills and its deep rift-like dales. The rounded tops are brown or black from heather moors and peat bogs, swept by the damp moaning winds. No tree is visible; only an occasional strip of hedgerow along a sunken path. The gentle upper slopes have a fresh green sward studded with low prickly gorse or whin, and chequered with fences of broom. Lower down, the oak trees which formed strips of wood along the brooks in the upper part spread all over the steeper slopes, forming a continuous covering. There, old holly trees thrive on damp carpets of woodruff, wild hyacinth, ferns, and mosses. A 'hoe' with a cottage and a green stands out here and there on the wooded slopes. Thence,

the cliffs sink precipitously to the sea, with a gorgeous covering of flowering sloes and gorse, interspersed with patches of russet and pale green bracken.

This is essentially a sheep, cattle, and pony farming district, where agriculture plays a less important part. It has a scanty population. Winter and summer are fairly mild except on the heights. Rain is abundant all the year round; the sky is often cloudy and the wind strong, especially in winter; the soil is remarkable for its red hue, and the rock below consists of a shaly red sandstone.

Hampshire. Quite a different landscape is seen in Hampshire, south of the North Downs (near Winchfield). It is a gently rolling plain, apparently covered with continuous forest. Tree growth is luxuriant and abundant; the oak is conspicuous everywhere. Roads are overhung and fields are encircled by hedges of oak, hawthorn, maple, guelder-rose, and euonymus, draped in wild bryony and hops, honeysuckle and anemone. The commons are shaded with many stately old oaks, under which pigs roam freely. Fields, greens, commons, and orchards seem but clearings in the woodland. Villages are buried in verdure. From a slight eminence the whole district appears a continuous canopy of oak. This is a drier district, with a fresher and deeper yellow chalk clay soil.

The Fens. Another characteristic region is the fenland round the Wash. This is a vast marshy flat, often flooded by its broad and sluggish rivers, chequered by narrow dykes and broader drains, as the drainage canals are called. It is a land of soft and far horizons, edged with poplars and windmills. The broad acres of rich wheat fields, juicy meadows, and marshy pastures are crossed by lines of poplars, willows, ashes, elms, elders,

FIG. 1*a*. An Oak Forest. (Photo: S. Maugham.)

FIG. 1*b*. A Beech Forest.

Notice the contrast between the undergrowth in the oak forest and the absence of undergrowth in the beech forest.

and hawthorns. Along the ditches and dykes run waving fringes of reeds, rushes, and sedges, and waterlilies float on the calm waters. Every night mists hang over the damp surface. The winters are cold, and icy north-east gales render them more severe, but there are hot days in summer. This region is very like Flanders on the opposite side of the North Sea.

Scottish Highlands. As a contrast let us pass over the grassy dales of Yorkshire and the dreary Southern Uplands and take one of the few wooded glens of the eastern Scottish Highlands. There, as we climb the bold slopes of lofty hills, we find a well-marked succession of vegetations. Along the side of the stream is a belt of dark beech forest, its floor carpeted with wood anemone, sorrel, primrose, and wood hyacinth. Farther up are oak forests, but of a poorer type than in the southern lowlands. Scots pines and larches form a higher girdle of stately woods, interrupted here and there by grassy pastures and heather moors. The steeper slopes above form verdant swards of short alpine pasture with bushes of bilberry, cranberry, and other berry-bearing shrubs, while the terraces and flats are covered with peat bogs. The broad open plateaus on the top are barren grounds with soft mats of bushy lichens and decaying rock boulders coated with crust lichens.

Central Ireland. In the central plain of Ireland, again, we find a totally different scenery. Much of it is covered with a rough sheet of barren and impervious clay dotted with hundreds of tiny lakes; the climate is cool and rainy. The result is a vast peat bog, a black, spongy, shaky, water-swollen cake of sodden plant-remains, where sphagnum and other mosses, cotton grass, and heath grow profusely. Heather makes a low bush on the drier moss and knolls. Moor-grass and molinia grass cover the

Fig. 2*a*. A View on Dartmoor. (Photochrom Co.)

Fig. 2*b*. An Irish Bog. (Photo: R. Welch.)

banks. Sedges, cotton grasses, and rushes form the coarse wet meadows. Tufts of grass grow all along the streamlets. Sweet-gale hides the marshy slopes. Such morasses cover a large portion of Ireland. They are also found in broad tracts in Scotland, more particularly in the barrens of Caithness.

Different Environments — Different Vegetations. Thus we find within our own islands different kinds of forests and woodlands, of pastures and meadows, of marshes and swamps. These are formed of different sorts of plants, arranged in different ways, growing differently, and having different aspects and modes of life. Apparently plants do not grow indifferently anywhere. Different sets of plants are found in different landscapes, and indeed they often form the distinguishing feature of the landscape.

Let us use the word *vegetations* for such groups of plants as are usually found together in different districts. We can then say that the *vegetation* differs as we climb from the base to the top of a mountain, as we descend the hills to the plains, as we pass from the east to the west of England, from the chalk downs to the fens, or from these to the central plain of Ireland.

But these districts differ in more than vegetation. We noted hills and plains, undulating and flat districts; red sandstone soils, black earth, whitish chalk clays, stiff boulder clays, and even bare rock. The climate also varied in each case, in one place more cloudy and rainy, in another clearer and drier; in one district always mild, in another, with cold winters and hot summers. These and other features differed in each instance. The sculpture of the district, the climate, the nature of the soil, and the other circumstances, all of which we may call *physical conditions*, varied as well as the vegetation. We are

thus led to conclude that differences of vegetation may be associated with differences of physical conditions. This will help us in our further studies.

Like vegetations in like surroundings. We shall now look around for landscapes similar to those which have just been described. For instance, the physical conditions and the vegetation of Exmoor are reproduced more or less exactly on Dartmoor, in Cornwall, on the hills of south-western Wales and of southern Ireland. The landscape of central Hampshire may be compared with certain parts of Normandy in France. Similar physical conditions and vegetation are found on the downs of southern England and on the chalk heights of the north of France. The Fens are but a replica of the lowlands across the North Sea. The moors of Yorkshire resemble in many ways those of the Southern Uplands. The eastern Scottish Highlands are very much like parts of the Central Plateau of France or the Fjelds of Scandinavia. In each case we find that the circumstances of climate and soil and the nature of the country are very much alike. So we are led to expect like vegetations in like surroundings.

Plant Geography. Clearly plants are not distributed indifferently everywhere. Their distribution is controlled by many circumstances which we term *physical conditions*. Had we observed the plants themselves more closely we should have noticed how the same plant assumes a somewhat different aspect in different surroundings. We should have been led to think that the nature of the physical and other conditions, which we call the *environment*, imparts a special appearance to a plant or a group of plants. In other words, only those plants will live and reproduce themselves which assume certain modes of living and growing in response to the

conditions by which they are surrounded. This is what is meant when we say the *plants are adjusted to their environment.*

If we are justified in drawing such conclusions from the few instances already given, we must next seek to verify them on a larger scale and in greater detail. The study of the distribution of different types of vegetation and the way in which these types and their distribution are related to the other geographical conditions is called **Plant Geography.**

CHAPTER II

VEGETATIONS AND OCCUPATIONS

Different Vegetations—Different Occupations. Returning to the various landscapes we have examined, we may learn a further lesson.

Exmoor has good pastures. Agriculture hardly finds any place on those hills. The pastures support a fair number of cattle, ponies, and sheep. Therefore a large proportion of the population is occupied in looking after these and with dairy-work. Some of the inhabitants of the lower parts of the valleys where the climate is mild grow early vegetables and flowers.

Passing towards Hampshire, we find on our way the vales of Devonshire covered with richer pastures which feed thousands of prosperous-looking cattle and sheep. As we pass through the wooded commons of Hampshire we notice the acorns under the old oaks. This is cheap food for the pigs which roam about everywhere, and are

an important part of the farmer's stock. We are reminded of a time when England was largely covered with oak forests and the Saxons were mostly swineherds. Of these forests little remains to-day, and the crab apples that grew scantily among them have been replaced by apple orchards for cider making. Devonshire has long been known for its cider, equal to that of Normandy, another oak and apple country. Farther east the humble hops that once hung on the hedgerows have been trained on poles, and form the graceful pergolas of the rich Kentish hop-fields, which supply the hops for beer. The picking of these affords temporary employment, every autumn, for a floating population drawn from London and other towns.

The marshy tracts of the Fens formerly produced only tall reeds, but since the rich and heavy black mud and peat soils have been drained and dried we find here heavy crops of wheat and much market-garden produce.

The uplands of northern England and southern Scotland are crowned with moors and poor pastures; and the slopes are excellent for sheep, which wear a thick coat of wool. The wool was formerly washed, spun, and woven in the little villages and towns round the margin of the uplands, and some of these have grown into great industrial cities.

The eastern parts of the Scottish Highlands long supplied good pine timber. As the forests were gradually destroyed and replaced by moorland, cattle, sheep, and deer succeeded each other. Spinning and weaving followed as occupations of the people who inhabited the towns which sprang into existence round the base of the Highlands. The Grampians, however, may once more become an important timber region in the future, if they are properly replanted.

Turning to the desolate central plain of Ireland, we find little of economic importance. Peat fuel is the chief product, the value of which for smelting purposes has increased of late. When the peat is drained and manured it can be cultivated. Where this is not possible, as in the bogs of the far west, a scanty population can hardly eke out a bare living by rearing a few cattle and sheep. Many people go every year to Scotland and England at harvest time to earn a little money as labourers. Others seek a living in industrial centres or migrate and settle in far distant and more fertile lands.

From these examples we notice how the nature of the vegetation may determine the occupations and development of the people. Bearing in mind the influence of the environment on the vegetation, we may conclude that the environment influences the population mainly through vegetation.

Like Vegetation—Like Occupation. This is yet more clearly illustrated when we compare the development and occupations of the people in regions with similar vegetations. The rich vales of Devonshire, with their cattle, their dairy industries, and their cider, vie with Normandy in these respects. On both sides of the North Sea, the fenlands of the Wash and those of the Scheldt are prosperous granaries where the gaunt arms of the windmills mark a similarity of occupation. The hop-fields of Kent and Sussex and those of northern France appear as parts of similar regions. The bleak Scottish Highlands and the Scandinavian fjelds are strikingly alike in many respects. The Irish bogs find a replica in the German and Danish heather and moors. We might enlarge our fields of observation and find such similarities all over the world.

Causes and Effects. Our conclusion is that there exists a chain of causes and effects. The physical environment has conditioned the vegetation, and the vegetation has largely determined man's occupations and development, while man has altered the vegetation and even modified slightly the physical environment to his profit or detriment. The study of all these would be the full scope of **Plant Geography.** Our attention, however, may best be limited here to the first two points, and more particularly to the first.

We shall first make a general survey of the main plant landscapes of the world. This we may do conveniently by starting with the hot and wet regions of the equator, and working our way gradually through colder and poorer countries to the bleak circumpolar deserts.

PART I

MAIN VEGETATIONS OF THE GLOBE

CHAPTER III

SELVAS, OR EQUATORIAL RAIN-FORESTS

THE *selva* may be described as a roof garden on pillars. Above, in the dazzling sunshine, is a sea of verdure aglow with islands of gaudy colours, on and in which gorgeous insects, birds, tree frogs, and numerous small mammals are extremely busy. Below, lies a stupendous gloomy vault, crowded with pillars, encumbered with ropes and cables, hung everywhere with baskets of foliage and laid with a soft and elastic brown mat, hidden here and there by a mass of broad variegated leaves.

Such is the first impression of the equatorial rain-forest, the product of the ever-moist, ever-hot equatorial belt. It is found chiefly along the Amazon and its main tributaries, in the heart of Africa, in Burma, Assam, Bengal, and Malaysia. The sort of country for such a vegetation is either flat or rolling plains, or the lower slopes of mountains up to 3,000 feet. In these regions it may rain every afternoon and night in the year, or there may be one or two dry seasons, each not more than two or three months, when the drought is broken only by thunderstorms. During the rest of the year it may pour for days or weeks; everything is soaked in a thick grey mist. The temperature is uniform, varying from 70° to 85° F. (20° to 30° C.), with an average of

FIG. 3. Exterior Aspect of Selva or Rain-Forest. North Borneo, West Coast. (Photo : H. M. Lomas.)

about 77° F. (25° C.). Some notion of what such a climate is like may be obtained in the tropical palm houses of our botanical gardens.

The light is dazzling when the sun shines, for at noon it is always high in the sky. It often becomes too strong even for the green matter of the leaves which are exposed to it. This light, however, is stopped by the canopy: beneath, the forest is uniformly hot, moist, stuffy, and gloomy.

The outline of the canopy is irregular. The crowns of the trees, generally rounded or egg-shaped, jut out at various heights and are connected with each other by interlacing foliage. One must not, however, think of this canopy as being composed of bunches of huge, thin leaves like those seen in palm houses. The leaves are of moderate size, similar to those of magnolias or the usual rubber plant (*Ficus*) of our drawing-rooms, or pinnate, not unlike those of the ash, but much larger, or again fingered, like those of the horse chestnut. They are very mobile, and follow the sun in its daily course, drooping, expanding, or rising in a surprising manner, according to the strength of the light. They are frequently fleshy and glossy. The tree crowns do not form compact masses, but are divided into separate bunches.

It is difficult to realize the variety of trees in the selva. The same tree only occurs two or three times in an acre, hence the irregularity of the upper surface. The intermediate vegetation which forms the pits, hammocks, or sheets between the crowns consists of lianas or huge climbers, several hundred feet long, and of the heads of the taller palms and minor trees.

At any time of the year we may find some plants bursting into leaf and others shedding their leaves, some gay with flowers, others bearing their fruits, for it is

always hot and moist, and there is no regular seasonal change affecting the whole of the vegetation.

Fig. 4. Canopy of Selva.

This upper tier of the great forest is bustling with life, though nothing of it is seen from below. There are innumerable insects, tree frogs and newts, lizards, tree-snakes, birds, squirrels, apes, and many other tree-

dwelling mammals, most of which never touch the soil in their lives. The majority are brightly robed,

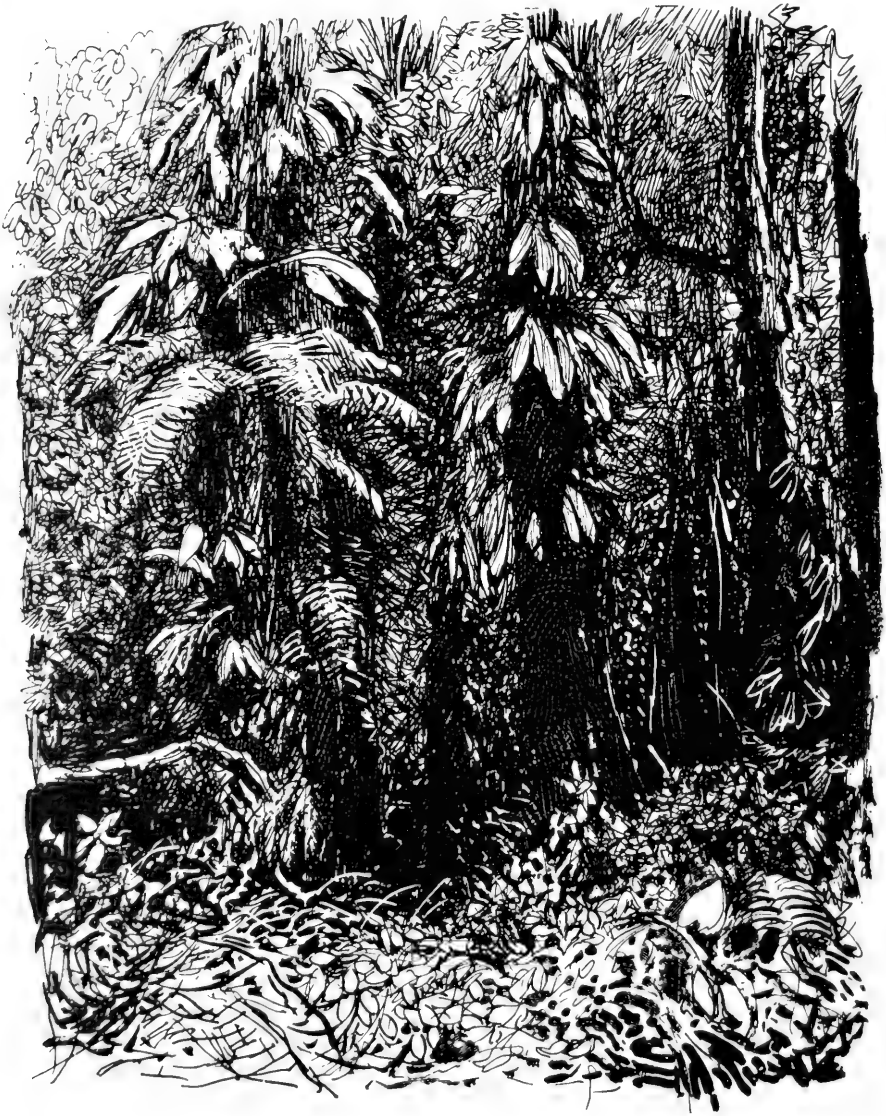

Fig. 5. Interior of Tropical Rain-Forest. Lianas, climbers, epiphytes, carpet.

plumed, or furred. Below the canopy is a sombre, damp, stuffy, silent vault, supported by long, slender,

unbranched tree-trunks, with a thin, smooth bark. Huge vines or lianas, varying in thickness from a man's thigh to his thumb, hang and twine in the most capricious manner from the roof, making a network of cables and

Fig. 6. Ground Vegetation of Rain-Forest. Large and tender-leaf plants on mould.

ropes, some smooth, some prickly; all bare and unbranched. They are frequently gorged with water and milky sap. These lianas have climbed up the tree-trunks and afterwards freed themselves from their supports; some hang direct from the canopy, coiling and twisting on the ground, and forming a tangle in

which progress is difficult; others, such as palms and arums, cling to their supports and develop bunches of huge thin leaves.

From every available nook and corner on the stems of trees or lianas grow hanging baskets of plants called *epiphytes*, i.e. plants living on other plants. Among them are many orchid plants, but the commonest are shaped like those of arums and pine-apples. An abundance of moisture in the air and the mould which falls from the roof enable these aerial gardens to attain a great luxuriance.

Scattered here and there, a lower tier of the forest may be found. It is made up of straight palms which often reach the roof and become entangled in it.

The undergrowth is formed by a brush of thin, weakly, unbranched, drawn-out saplings, generally fleshy and juicy, resembling overgrown herbs. In places one may find carpets of arums, dwarf palms, and other herbs; or again rosettes of variegated or brightly coloured leaves. A soft brown felt mat, in which stumps, trunks, and lianas are left half buried and decaying, often covered with orchids and other epiphytes and saprophytes (= plants living on decaying vegetable matter) completes the picture.

Two other features of the selva must be noted here. In many tropical forests certain kinds of trees are supported at their base by roots growing out of the trunks and resembling wings or props. These supports may reach 8 to 10 feet in height and as many in breadth, and are called plank buttresses. Another characteristic is that some of the larger and many of the smaller trees develop flowers and fruits directly on the branches and sometimes on the trunks as well as on the smaller twigs. This is well seen in the cacao tree.

This great gloomy forest hall appears to be deserted by animals. An awe-inspiring silence prevails, except for an occasional reminder of the life above. Animals can hardly be perceived owing to the subdued colours of their skins. The buzz of mosquitoes is heard, an

Fig. 7. Plank Buttresses of Large Trees in Tropical Rain-Forest. Lianas.

occasional newt, lizard, or snake is seen, but no other sign of life is apparent.

That such conditions are unfavourable to human development is shown by the inhabitants of the great forest. It may teem with undeveloped wealth, but this is almost invariably out of reach. It is mostly by destroying the forest that man has discovered how to use the ground. Only in clearings can he cultivate the necessary

plants: and to do this he has to fight the forest, which grows so quickly that it constantly threatens to overwhelm him and his fields. Communication through the forest is dangerous and difficult. Hunting, fishing, and collecting the natural products are the chief occupations of the people, and these involve a wandering life. The real inhabitants of the selva are nomad hunting tribes of the most primitive kind, scattered over immense areas.

The large permanent clearings and the margins are peopled by settled races, leading a more complicated life. When the forest is dealt with by modern implements and methods it can be transformed, and this has been done in parts of South America and Malaya, where gardens of extreme fertility have been formed. One by one the natural products of the forest are being cultivated. From the selva have come the banana, cacao, manioc, yam, mamey, mango, papaw, sapotas, aguacate, bread-fruit, cabbage-palm, vanilla, sugar-cane, sugar-palm, betel-palm, spices, and many other food products, as well as many industrial products such as caoutchouc rubber, gutta-percha, palm-oil, and countless others. Rice does well under the equatorial climate, of which it is one of the most important features.

All equatorial rain-forests are not so dark as the type which has just been described. More open varieties are found in which the undergrowth is more luxuriant and the distinction between the canopy and the interior is consequently less marked. Such forests are even more impassable than the dark columnar type. Palms play a more important part. The flood-forest of the Amazon, with a dense, continuous, flowerless, cheerless canopy of uniform verdure, and a marshy floor, resembles a close crop of giant tree-weeds.

Among other varieties of the hot rain-forest may be mentioned the bamboo forests of Assam and Burma, partly due to cultivation, and the swamp-forests of Burma, Sumatra, and Borneo, completely bare in the rainy season.

In such hot and moist climates, forest growth can only be checked with difficulty. The land which is not under permanent cultivation is soon conquered again by a dense jungle, the first step towards the reconstruction of the selva. This is known in South America as *Capoeira* or *Capuera*.

CHAPTER IV

MANGROVES

THE imagination of seamen and other travellers in tropical seas was early struck by one form of the wooded coastal swamps which sometimes rises to the rank of low forest. The impressive aspect and deadly properties of it have gained for it a personality—a name: the **Mangrove.**

Mangroves are found along rainy, inter-tropical shores on the low, flat coasts lying inside the surf-belt, but within reach of the tide, where the water is somewhat quiet. They extend inland in the brackish lagoons and swamps. They may form a fairly continuous fringe or be split up into a labyrinth of islets between which the sluggish tidal streams run.

At high tide the mangrove appears like a mass of green, grey, or dull blue foliage sitting on the water—a flooded forest. As the tide recedes it gradually reveals

a low forest of ungainly tree-weeds. Their short and shapeless trunks, covered with mud, are supported by a tangle of crooked bow- or knee-shaped stilts emerging out of soft blue-black slime. A stinking gas bubbles to the surface of the rotten mire, which teems with a crawling population of crabs and fishes.

A uniformly hot and wet climate, salt or brackish water, a soft ground deprived of air, and the rhythmic tidal flood are the conditions under which mangrove plants develop. Their life is one of steady, monotonous growth and decay, without interruption, with no other rhythm than that of the tides and of the alternations of equatorial downpours and scorching sun. They are evergreen, and, as plants do not readily absorb salt water, their foliage is protected against excessive transpiration, being now thick and leathery, now fleshy, now provided with a glossy impervious skin, now with a woolly down. The trunks and branches are soft and juicy, capable of storing water. The roots are specially adapted for fixing the trees in the soft ground by a spreading scaffolding of stilts or buttresses. Sometimes additional roots grow down from the foliage and striking in the mud support the expanding crowns. On account of the difficulty of breathing under water or slime the roots bend, arched or knee-shaped, above the low water level. Or, covered with breathing mouths, they crawl, jointed or in coils, over the mud laid bare at ebb tide. Or again they send up out of the ground special breathing stumps of various shapes. In some species of mangrove bushes the seeds sprout on the very boughs and, like arrows, drop vertically in the mud where they strike roots. Mangroves are more frequently found as shrubs than as low forests. They are useless to man, extremely unhealthy, and uninhabited.

Fig. 8. Mangrove at Low Tide.

CHAPTER V

MONSOON FORESTS, OR SUMMER RAIN-FORESTS OF THE HOT BELT

Besides the lofty evergreen rain-forest there exists in the tropics a large variety of forests and woodlands which experience one well-marked period of drought every year. These forests, which differ greatly in aspect and composition, and range from the lofty type to that of the high bush, may conveniently be termed **Monsoon Forests.**

Their distribution coincides with that of the true monsoon rains (India, Burma, Indo-China, and northern Australia), or with the lands which receive rains during summer, i.e. on the tropical margins of the equatorial rain-belt in Africa, round the shores of the Gulf of Mexico and the Caribbean Sea, and the north and eastern portions of South America.

A hot climate, abundant summer rains, and a prolonged drought lasting from four to six months, are the conditions which determine the appearance of the Monsoon Forests. The total amount of rainfall is smaller than in the equatorial rain-belt, and the difference of temperature between day and night and between cold and hot seasons is more strongly marked. To these conditions may be added the occurrence of strong dry winds.

Monsoon vegetations vary in appearance from an impoverished type of rain-forest to that of the lower mixed type of Burma, which is only 30 feet to 40 feet in height and in some respects not unlike our oak woods.

In comparison with the rain-forest, monsoon forests are more open. There is no such scramble of all plants for light, as the trees are farther apart. In the dry season most trees shed their leaves, and the landscape

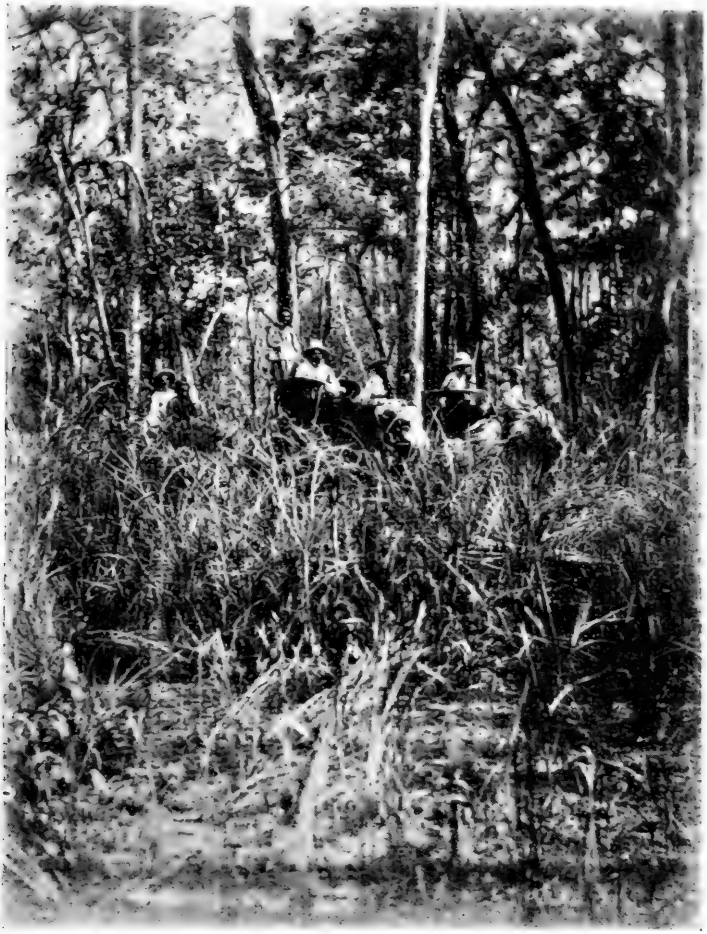

Fig. 9. Monsoon Forest. Kaing Grass. Upper Burma. (Photo: Col. Couchman.)

has a wintry appearance. Even in the period of vegetation, some light pervades the forest and plays in the undergrowth. The trees are from 40 feet to 100 feet high, and massive. The crown assumes great impor-

tance. Trunk and branches are stout, sometimes knotted and gnarled, with a thick, fissured, scaly bark, and the branching is abundant and starts at no great height. In most cases the crowns are round and large.

In this forest there are three tiers, or layers: the canopy, which is very much interrupted, the undergrowth, and the ground carpet. The leaves in some cases, as in the teak, are larger than those of the big trees in equatorial selvas, but they are thin and simple. The lianas and the climbers are fewer and smaller, the latter being mostly herbaceous. Epiphytes are found only in the canopy. As a consequence the undergrowth consists of thickets of woody shrubs. Often, however, it is replaced by a tall tufty grass.

The chief feature of this monsoon vegetation is its well-marked periodicity. In the dry season which precedes the rain the numerous bulbs flower. At the onset of the wet monsoon all shrubs blossom before the leaves appear. Teak is found in flower and leaf at the same time. Herbs follow suit in the course of the rainy season. As in the selvas, the variety of tree species is quite remarkable. Some forests contain from forty to fifty kinds of trees. The teak forests, however, are more uniform.

Types which most closely resemble the rain-forest are found in Central America and the West Indies, in Upper Guinea, and on the northern margin of the evergreen Central African selvas.

In India and Burma varieties described as *higher mixed forests* (120 feet high) and *lower mixed forests* (70 feet to 80 feet high) have a longer dry and consequently leafless period.

The most typical instance of the monsoon forest is the teak forest called 'Jati-Forest' in Java, where the alternations of the dry bare stage and the rainy

luxuriant stage, an adjustment to periodical droughts, are beautifully exemplified.

Lighter and lower than the teak forest are the so-called 'low forest' and the Eng-forests, which grow in Burma on poor soil.

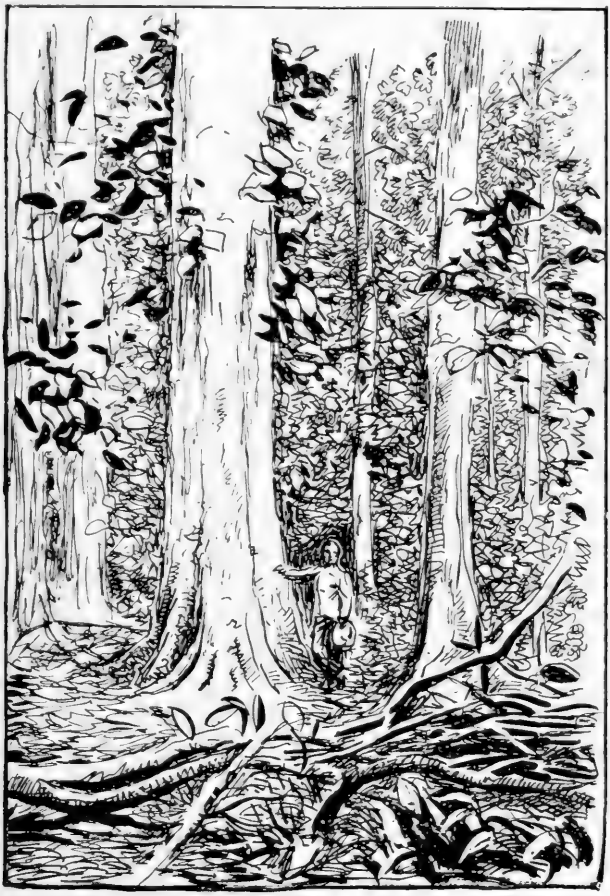

Fig. 10. Monsoon Forest. Teak in Java.

The common feature of these otherwise somewhat dissimilar forests is the regular falling of the leaves, which corresponds to the recurrence of the dry season. Though there be enough water on the whole to support tall trees, those trees will flourish best which provide

against an excessive loss of water in the dry season by shedding their leaves. The foliage, which exists only through the rainy period, needs no particular protection.

Since the conditions to which plants must adapt themselves in these monsoon lands are more numerous than in the regions of hot rain-forests, the plants which succeed in doing so are fewer in number but

Fig. 11. Light Tropical Forest in Central Africa.

display more variety. With less moisture in the air and in the ground a smaller quantity of vegetable life can subsist on each acre. Hence trees are both lower and more scattered. But having more space, they develop stronger, if lower, crowns. Receiving more light, they grow stout trunks and branches; and the undergrowth is dense and woody, but with small and hard leaves. The huge lianas of the equatorial rain-forest do not find enough water here and are replaced by humbler climbers.

The monsoon forest areas are perhaps less rich in natural resources than the hot rain-forest, but they are healthier and more easily cultivated. Less awe-inspiring and overwhelming, they are more favourable to human settlement. Teak, a strong hard timber, is the most widely known and useful product of these forests. From early times use has been made by man of the monsoon regions, where a prosperous tropical agriculture has developed in many places. Maize and millet can always be grown. Oil palms, coffee, kapok trees, shi-butter trees, and many others flourish. Irrigation, which is in most cases easy, allows the cultivation of rice, sugar, banana, and most equatorial produce. It is not unlikely that a part of India where there is now a dense population was once covered with this lighter kind of forest.

CHAPTER VI

TROPICAL THORNWOOD OR CAATINGA

An African traveller describes the landscape of the thornwood as follows:—

'An endless, impenetrable jungle of leafless and flowerless bushes and trees. . . . Grey is the tone of the landscape, grey the stony ground, grey to silver-white are the bark and twigs of the trees and bushes closing in on both sides of the track and forming an impenetrable wall. Countless thorns resist any intrusion except that of one single enemy—the axe of man. Large grey lizards

sun themselves on the boulders along the path. Lively grey monkeys now and then appear on the tree branches, the only sign of life in these deadly calm surroundings. Here and there stately crowns of umbrella-shaped acacias rise above the grey scrub, and the grotesque dull green limbs of the candelabra euphorbias break through the thornbush and stretch to heaven as if in dread.'

This lower type of tropical woodland, also subject to long droughts, is chiefly displayed in north-eastern Brazil on the eastern tableland, in Mexico and Central America, in the Lesser Antilles, Venezuela, and the Guianas. In Africa it is to be found in western and eastern Sudan and East Africa. It exists in some parts of the Deccan, and forms a belt in the hinterland of northern Australia.

A high temperature prevails all the year round, ranging from 59° to 95° F. (15° to 35° C.). The dry season lasts from six to eight months. In the comparatively short wet season there is a moderate to scanty amount of rain, much of which falls in storms. The annual rainfall may vary from 16 to 40 inches, and shows great irregularities from year to year.

The typical tropical thornwood is a close jungle, 10 to 15 feet high, bare of leaves for six to seven months; a tangle of leafless, loose, brittle, and dead-looking thorny bushes, in which acacias play an important part. The high scrub is studded with low, flat-crowned, umbrella-shaped trees, often bristling with thorns or prickles; with a few evergreen trees or shrubs whose hard leathery leaves are covered underneath with a brown prickly wool; also with tall, thick, prickly cacti or cactus-like euphorbias in the shape of chandeliers; with barrel-shaped trees like huge water bags bearing a crown of a few short, stout branches; and with rosettes or tufts

of long strap-like, prickly leaves of pineapple-plants and others resembling the dragon-tree or the aloe. These act like barbed wires, and increase the difficulty of passing through the scrub. Ragged patches of

Fig. 12. Tropical Thornwood or Caatinga in Brazil.

epiphytes, resembling lichens and mosses, hang from trees and bushes. The prickly wires of a few dry vines are found creeping or climbing. Grass is rare, and only occurs in scattered tufts of dead, brittle straw. Such is the appearance of this thornwood during the greater part of the year.

When the rain sets in there is a sudden change. The dead-looking scrub covers itself with gorgeous flowers, and the air is laden with perfume. In a week's time the buds have swollen and burst. A shimmering pale green clothes the landscape. A few days more and there is a sea of fresh verdure dotted over with flowers. Innumerable herbs spring from the soil. The dry straw-like tufts open, and the face of Nature is entirely rejuvenated.

The types of thornwoods are varied. Instead of a close jungle there may be (1) a thinner, more open brush; (2) a sort of park-like formation, made of more or less extensive thickets, with bare open spaces; (3) a very scattered formation where some trees stand alone or are fringed round with a hedge of thorns, and a few thickets dotted over the bare, or sometimes sparsely grassy, ground; (4) a close, treeless brush, studded over with evergreen shrubs; (5) a still more barren form of rocky, broken ground, with patches of bush and a prevalence of cacti and similar plants, tall ones like chandeliers or organ pipes, or low globular ones like prickly melons. In Brazil this kind of scenery is known as the sertão.

To explain this vegetation we must remember the physical conditions. They are: an active, continuous evaporation; a long dry season and a short rainy one; strong light, and no winter. The soil is generally poor or permeable, consisting of sand, granite gravel, or fissured limestone, which absorbs water readily. There are very few permanent streams of any size at the bottom of the canyons.

The prevailing drought, which is broken only by a short rainy season, necessarily places severe limits on the number of plants which are able to maintain life

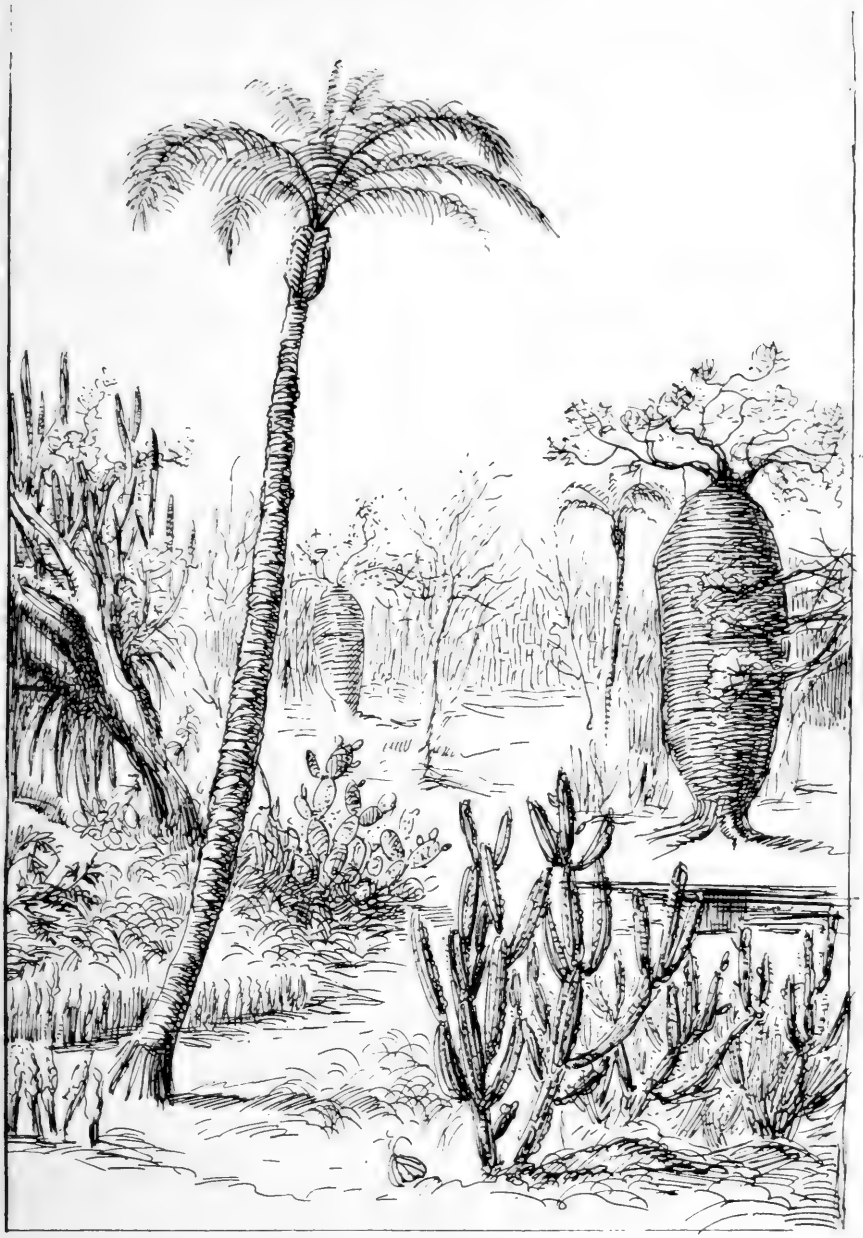

Fig. 13. Tropical Thornwood in Brazil. Cacti, prickly pears, barrel trees. (After Martius.)

under such conditions. Plants are compelled to lead a dormant life most of the time and then make sudden use of what scanty rains they get. During the dry season the sun scorches the leaves in a short time. Leaves are the organs through which moisture is pumped out of the plant. Those plants which can dispense with leaves altogether during the dry season are therefore more capable of surviving; next in order of adjustment are shrubs or herbs whose thick leaves are encased in a leathery impervious sheath, often coated over with wax, resin, or gum, which protects them against the excessive light and prevents undue loss of water. Hence in many of these plants gum, wax, oil, resin, &c., are exuded. In some plants which have no leaves to speak of, the work of the leaves is carried out by their stems and branches, where green matter is found more or less deeply seated under the skin. This implies a continuous and slower growth. Such plants store water in their spongy, fleshy tissues, e. g. cacti, candle-trees, euphorbias, pineapple plants, and aloes. The shape of some of these strange plants suggests huge water-barrels. But even in the wet season the rain is irregular and scanty. Water is quickly evaporated, and the leaves have to be protected against excessive perspiration. This is effected in many cases by movements of the leaves, which either droop or so turn their edges as to present the least surface to light and heat, and follow the sun in its course. Leaves divided into leaflets respond most readily, because these are lighter and are easily spread or contracted, as in the mimosas and acacias with which we are familiar.

The closeness of the plants is regulated by the nature of the soil and the amount of water in it. Plants drain the soil, and too many of them will dry

it up, so that only the hardiest survive. Where therefore the ground is rocky and offers but few places where roots can be inserted, or again where the soil is too pervious and dry, plants naturally stand wider apart. Grasses with shallow roots have little chance of surviving in such conditions. The plants of the caatinga have strong roots, branching and penetrating far down into the ground. It is difficult to extirpate them and so clean the soil for agricultural purposes. The function of the prickles, thorns, and similar outgrowths is not precisely known.

The scarcity of water causes the whole vegetation to be reduced in height. Growth is necessarily slow. Moreover, tallness means more exposure to wind and greater evaporation. Hence, while trees are the rule in the monsoon forest, they are the exception in the caatinga. They are lower and less exposed, and their needs are very moderate; there is more space available for shrubs.

The rhythm of life in thornwoods is even more strongly marked than in the monsoon forests. Indeed the caatinga may be described as a much impoverished monsoon forest. As mentioned above, in the dry season the plants look lifeless, but as most of them have water and food reserves, they burst into bloom at the first onset of the rains. This is probably a necessity of their existence. If it were otherwise, and plants did not flower until later on, they might not have enough water left for the completion of the seeding process, and so would disappear entirely. After flowering comes leafing, ripening of the fruit, and building of the leaf-bud. This is followed by leaf-shedding and the spreading of seeds. Then comes the period of sleep.

The thornwood or caatinga areas are generally

barren and useless. They are generally avoided by man. In some parts of Brazil and East Africa they have been cut down, burnt, and replaced by coffee plantations. Where irrigation is possible, maize and cotton can be cultivated. In Mexico, parts of the caatinga yield fibre-producing agaves.

CHAPTER VII

THE SAVANA

We have traced a gradual change from the rain-forest to the deciduous bush or caatinga, and now we have to examine another and poorer form of vegetation in the grass formations of the Savana (or Savanna), Campo, or Llano.

The savana covers a vast area in South America, north and south of the Amazon forests, also in Africa, in the Sudan, and the East African Highlands. It is found round the Kalahari as far south as Natal. In Australia it stretches in a circular belt round the central desert.

The climate is hot, with a moderate range of temperature. The extremes vary from 32° F. (0° C.) in the coldest nights on the subtropical outskirts to 97°–104° F. (36°–40° C.) in the warmest days. The average yearly rainfall is from 40 to 70 inches spread over 120 to 190 days; and there is a prolonged period of drought lasting from four to seven months. The moisture in the air is greater than in caatinga. Considerable irregu-

larities in the amount of rain occur from year to year. The wind is strong at times.

The savana presents mostly a park-like appearance; a landscape of tall grass and scattered trees. In hollows the trees frequently form woods; on ridges they are sparse or wholly absent. But, though primarily a grass land,

Fig. 14. Orchard Savana in West Africa.

the savana does not resemble our meadows. The grass is commonly from 6 to 10 feet high, with a dry appearance. It makes a dusty yellow straw and is clustered in dense, stiff, tall tufts, crowned with waving silvery spikes similar to those of the pampa grass, and showing in the intervals patches of bare, parched soil, coloured light-red, orange, or dull yellow. The savana becomes in places a perfect tangle of giant elephant-grass, 12 to 15

feet high and quite impenetrable. Other places have a thinner sprinkling of lower and softer species.

Interspersed among these grasses are dry-looking shrubs and small trees. Some of them are low bushes with hard, leathery, evergreen leaves; others are bare and prickly, like thorny acacias or gooseberry bushes in winter; others still have smooth, swollen, fleshy stems and twigs bearing bunches of small leaves. The grass-land may also be crowded with leathery, prickly, stiff herbs resembling pineapple-plants. There are many varieties of trees.

Among the several aspects of the savana may be distinguished: (1) rolling downs, the troughs of which are occupied by clear, dry-looking, loose woods of small trees, from a few yards to a mile or more in extent. These have been called oases by some travellers. Along the rivers or streams are fringes of more luxuriant forests. (2) Flat, monotonous tracts of tall grass studded with isolated palms or with extensive palm groves. (3) Grassy bush-lands dotted over with mushroom- or umbrella-shaped trees, with flat crowns. (4) Impassable tangles, 12 to 20 feet high, with low trees giving them the appearance of orchards of crab-apple trees overgrown with giant grasses. The trees are similar in aspect to our stunted, gnarled, and knotty coppice oak, with thick, corky, fissured bark. (5) Open lands, covered with grass 3 feet high, the home of the giant of the savana, the baobab tree or monkey-bread, and other similar bombax and ceiba trees. The monkey-bread tree recalls an old giant oak, less knotty and twisted, but more fleshy and swollen. The crown is not dense, but spreading and patchy; the colossal trunk is not high, but stout, some 12 to 30 feet in diameter, with a smoother bark than that of the oak tree. The baobab

requires free space all round: it cannot live in a crowded place. There are also (6) treeless tracts of comparatively short grass, with occasional candelabra euphorbias. The

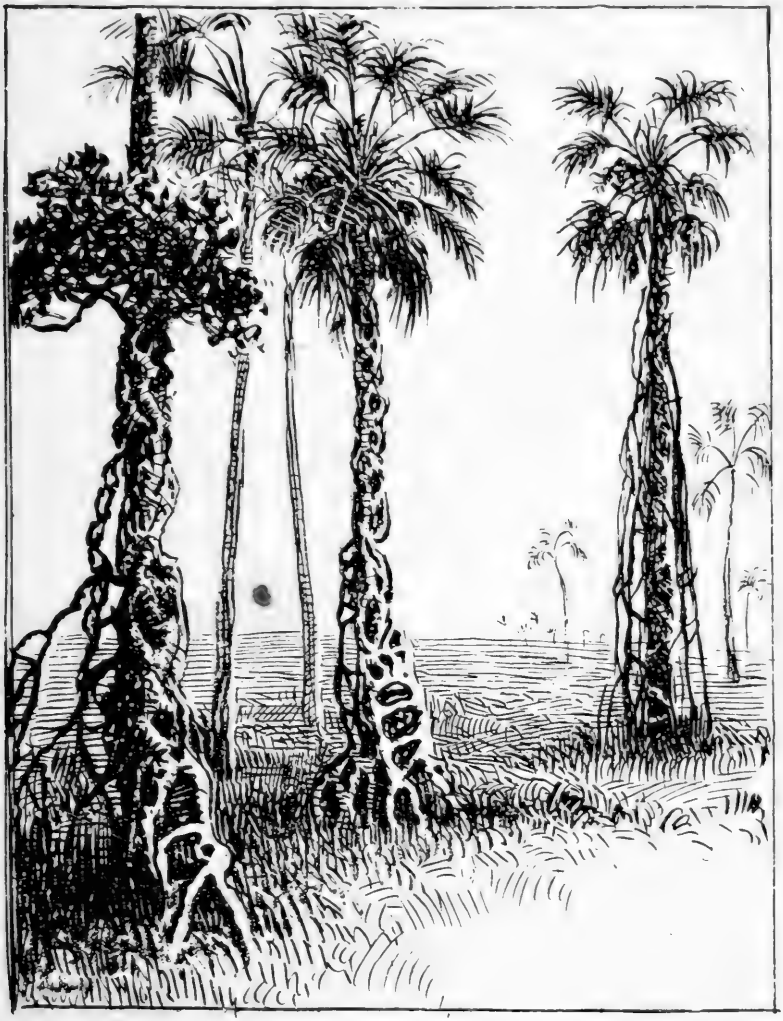

Fig. 15. Llano in Venezuela. (After Sachs.)

savana may pass gradually into the tall bush called the caatinga.

The climate of the savana differs from that of the monsoon tracts in having a longer period of drought and a

greater irregularity of rainfall, and from that of the thorn-woodland in having more frequent rains. The soil is less permeable and more moist than in the porous and dry caatinga lands, where there is no grass. The climatic conditions cannot favour the development of such heavy masses of vegetation as the deciduous forests of the monsoon type. Humbler forms are alone tolerated here. Tree-growth is restricted to places where the ground water lies at no great distance from the surface. Only trees with roots long enough to tap this ground water will thrive in the savana. Most of the savana woods or oases are found in the hollows which are nearest the ground-water level or where surface water tends to accumulate. The remarkable capacity of some trees for storing water in large quantities renders them more independent as regards the soil; such are the baobab, bombax, ceiba, and others. But palm-groves are confined to places with sufficient ground water. Indeed the presence of certain trees like the ceiba, mitragyne, borassus- and dum-palms, is a sure indication of water at no great depth below the surface.

Most savana trees except palms are bare during the dry season. A few others are evergreen, but their leaves are sheathed in a leathery impervious skin, and their bark is thick and corky. The crowns of these trees are low and compact. A noteworthy feature is the umbrella-shape of the majority of these, due to the blighting of all outstanding buds by the wind. The form thus given to the crown of the tree enables it to act as a sort of wedge upon the strong winds that blow frequently over the grass-lands.

That the characteristic growth-form of the savana, namely grass, is able to withstand prolonged droughts may be partly accounted for by its peculiar structure.

Savana grass grows in compact tufts with strong roots. The straw of previous years accumulates and forms a sponge, well covered and protected against evaporation, and this sponge is continued below in the bulky and close felt-work of the roots. These masses store a certain amount of water and help the plant to live a dormant life through the dry season. The isolated tufts leave the bare soil visible between them.

In many savanas the grass is mixed with a number of hardy perennials and small shrubs, evergreen or deciduous

Fig. 16. Umbrella Trees in Savana. East Sudan.

and thorny. Tubers and bulbs are also important elements of the vegetation. These water-storing devices allow a vast number of plants to lead a slow life underground until the recurrence of the rainy season, when they burst forth into leaves and flowers. They are common to all dry countries.

There is no doubt that the savanas have been artificially extended and that many kinds of plants in them have disappeared, thanks to the custom of yearly grass-burning. In Africa, for instance, the grass-land has encroached upon the monsoon forest, and even upon the high rain-forest itself. In the natural savana, tree-growth

has been either prevented or greatly reduced by such fires, which are started with extreme facility.

The park landscapes of the savana all over the world are eminently suited to animal life. Innumerable herds of antelopes, buffaloes, zebras, and giraffes, together with elephants, rhinoceroses, and many others, feed on the grass and trees, and are themselves the prey of carnivorous animals.

With a sufficient rainfall and a fair soil, great natural resources, an undulating surface and easy communications, the savanas offered man the possibilities of hunting, cattle-breeding, agriculture, and trading. By means of irrigation he can grow there all the products of the tropical and equatorial belts. Peoples engaged in these various pursuits have occupied the savanas together and fought against each other. Some of them have at one time developed a high state of civilization. Thus, in the grass-belt of the Sudan, south of the Sahara, the prosperity of the settled agricultural communities has been more than once destroyed by invasions from the nomadic pastoral tribes. At present the savana lands offer to man one of the most promising fields for activity.

CHAPTER VIII

TROPICAL SCRUBS OR SEMI-DESERTS

The Acacia Semi-Deserts are usually included among and described as deserts. They form a transition between deserts proper and the savanas, or between deserts and thornbrush-woods, and possess some of the characteristics of both. Acacia scrubs are often found on stony moun-

tain sides, in rocky, rolling country, and on gravelly, pebbly, or sandy grounds exposed to the full glare of the tropical sun. They occur in some parts of Texas, Arizona, New Mexico, and Lower California; in the northern Sudan bordering on the Sahara, in Somaliland, in Arabia and other parts of the northern shore of the Indian Ocean, and in Australia. The climate and other charac-

Fig. 17. Tropical Semi-Desert in North Mexico.

teristics can best be described as intermediate between the absolute desert of the tropical Sahara and the thornbrush-wood. Occasional rainfalls are the only indications of a rainy season. The temperature at all seasons of the year is very high. The abrupt and great variations of heat and cold are sufficient to split the rocks.

The acacia scrub is the humblest form of savana or of thornbrush. The grass is reduced both in size and

quantity, and only meagre, thirsty, dwarfed, stiff bunches occur, scattered and isolated, or in ragged patches. The umbrella-acacia has dwindled to mere shrub size, and stands bare for the greater part of the year. An occasional undergrowth of a heathery or sage-like and withered appearance, and a few fleshy, thick, or leathery

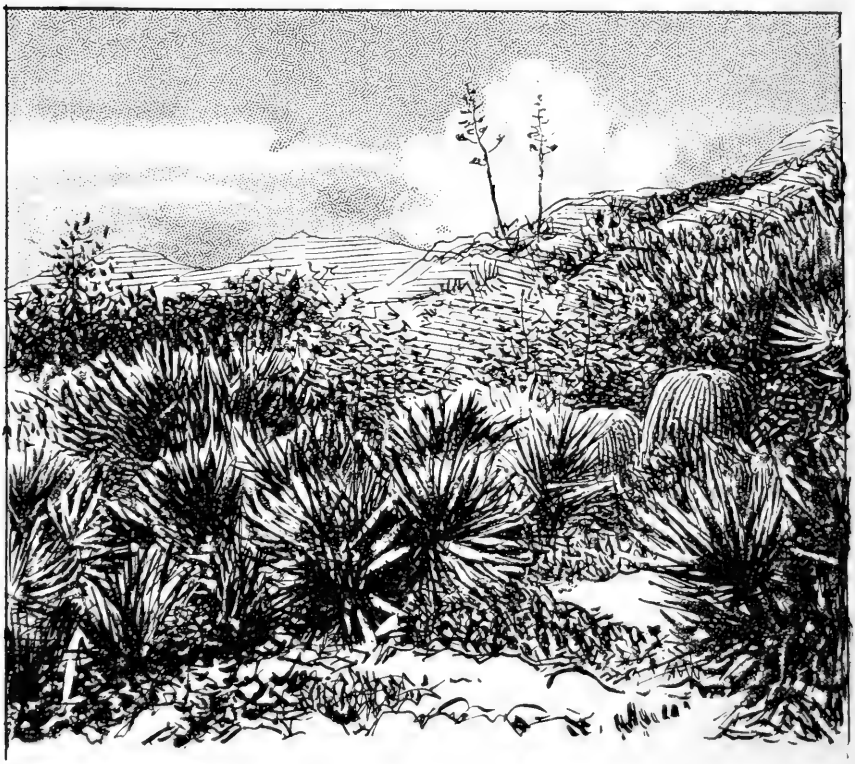

FIG. 18. Mexican Semi-Desert.

herbs may be seen now and then. The proportion of tubers and other underground plant reservoirs and food stores, resembling huge turnips or carrots, is much greater here than in either the savana or the thorn-brush. The bushes and low trees are set widely apart or else loosely grouped, but they seldom obstruct the view to the distant horizon. Looked at from above, the

ground appears as if it had been irregularly sprinkled over with a stiff and dwarf vegetation. In Arizona the abundance of thorns and prickles on fleshy, leafless cacti is very striking. In some parts of Africa the thorny and bushy acacias and euphorbias predominate, along with a sprinkling of stiff, wiry grass.

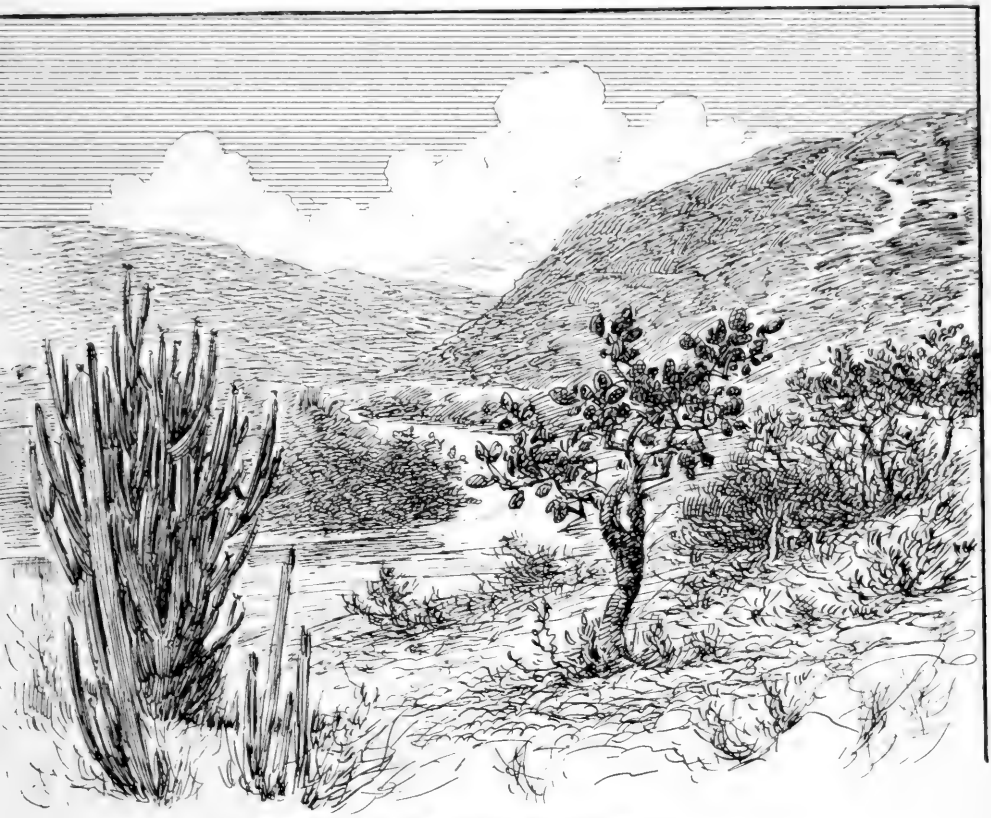

FIG. 19. Mexican Semi-Desert.

All tropical deserts are bordered by belts of arid acacia wastes, and these differ but little in aspect. Among the varieties of these barren lands may be mentioned, in East Africa, the semi-desert with succulents and occasional acacia bushes; in Mexico and Arizona, the cactus and creosote-bush wastes; in Texas, the yucca, opuntia, and

agave sotol ones; in Australia, parts of the mulga-scrub; in Sokotra, the adenium and euphorbia barrens; and in South Africa some parts of the Kalahari and Karroo. Such countries are unfit for human settlement. Only swift and hardy animals, such as the camel and the ostrich, can live in them. For all practical purposes they are hardly better than actual deserts.

Sub-tropical lands which are warm and dry throughout the greater part of the year have a large variety of scrubs and woodlands, intermediate in appearance and mode of life between the mediterranean scrubs and the tropical thornwoods. Such is the *espinal*, which covers a broad strip of land along the foot of the Andes in western Argentina and reappears in Chile. It ranges from low woods to bare stony flats dotted with spreading bushes not unlike cushions of long thorns and with candelabra-cacti. The most forbidding form of the espinal is the *chañaral*, so called from its chief component, the acacia-like chañar bush, remarkable for its huge thorns and tiny, divided leaves.

CHAPTER IX

DESERTS

One easily imagines vast, bare expanses of flat or rolling plains, sunbaked or windswept, sparingly dotted with low, dry, strange-looking plants, or destitute of any vegetation. But it is difficult to realize the beauty of the weird scenery of the desert with its merciless, overwhelming light, and the awe-inspiring silence of its boundless wastes. Vast areas of yellow sand-dunes, broken and rugged rocky floors, ruined scarps of naked hills sharply silhouetted against a deep-blue sky, are a few of the manifold aspects of the hot deserts.

Broadly speaking, the equatorial belt is hemmed in between two belts of tropical and sub-tropical deserts. We can follow the northern belt from California, Arizona, and Mexico across the Sahara and Arabia to the deserts of Iran, Turan, and the Shamo or great sea of sand of Mongolia. The broken links of the southern belt are found in the Atacama, Kalahari, and Australian deserts.

Deserts are caused by an absence of rain; but the cause of rainlessness may vary in the different regions. A single shower in many years; an excessively dry and clear atmosphere; cloudless skies; considerable and sudden changes of temperature, are the normal conditions of hot deserts. But the coastal deserts of the austral regions—in Peru and South-West Africa—are occasionally wrapped in mists.

The ground may be rocky, stony and gravelly, sandy

or clayey. When rocky or clayey, it is covered with cracks and fissures produced by the abrupt alternations of temperature.

Several varieties of desert climates have been distinguished. There are (1) the coastal deserts of Peru and Chile and of South Africa, which have alternations

Fig. 20. The Reg Desert. Sinai Peninsula.

of burning days and cool nights, when mists and dew may spread over the coasts; (2) the typical tropical deserts, of which the Sahara, Arabia, and central Australia are the best examples; and (3) the deserts of high latitudes with extreme winter cold, found in Central Asia. The nature of the ground introduces further varieties of desert. For instance, we find in the western Sahara the *Erg*, consisting of sand-dunes dotted over

with heath-like bushes and grass tussocks; the *Reg*, or pebbly-clayey desert, with half-buried cushions of prickly 'desert cauliflowers'; the *Hamada*, or stony, rocky desert, the most desolate of all, consisting of a floor of

Fig. 21. Desert in Arizona.

split and broken rocks and boulders, with an occasional plant-tuft anchored in the fissures. Then there are saline depressions, which are either entirely plantless or tolerate a few loose colonies of dwarf salt-bushes.

Passing over different types of the Egyptian and

Arabian deserts and the wormwood wastes of the Caspian, we find in the Asiatic deserts all transitions from the absolutely bare, moving sand-dunes and the low, scattered brushes of dead, wiry tufts of grass, to dense sandy heaths of tamarisk and small, leafless trees like the saxaoul. The American deserts are known for

Fig. 22. Desert in South-west Africa. Welwitschia.

the forbidding aspect of their giant cacti, their strange varnished creosote bushes, and other curious forms.

Desert plants have to depend on occasional showers at long intervals, or on the subterranean water coming from surrounding areas and from the residue of the scanty rain-water which has sunk into the ground below reach of evaporation. If the water-level is so low as to be out of reach, the plant becomes dormant, and lives (often for years) in the shape of dust-like seeds. Those seeds which have survived the long sleep will, on the first showers of any consequence, burst into an intensely active life of very short duration. They sprout, grow,

flower, fruit, and seed, all within two or three weeks. The desert will then be covered for a few days with a thin, bright carpet of flowers, which will disappear almost as quickly as it came. Some plants will live or sleep through a similar life, buried in the ground, by means of water-storing bulbs or tubers, resembling huge potatoes protected by a leathery, impervious, rough sort

Fig. 23. An Oasis in the Sahara.

of coat. They send out their temporary shoots under the stimulus of rain. Others again, more like dead and buried stumps, develop with extraordinary slowness trailing, strap-shaped leaves that seem to be without beginning and without end, dying at one extremity and growing at the other. In other instances the plants possess such impervious coats that they hardly lose any water, and their roots are quick to take advantage of the slightest moisture that may come within reach. These plants grow above the ground in the shape of cushions, pillars, or even chandeliers, like the cerei and other cacti of the American deserts.

In less arid conditions, where water may be had within thirty to fifty feet of the surface, some plants seem to send their rope-like roots down to those depths. In fact, so enormous may be the length of some roots that in the excavation of the Suez Canal roots were found in its bed belonging to trees growing on its banks. Such plants can then develop into bushes or low trees. Of course, they are clad all over with a leathery, impervious armour against desiccation. The sheath in most cases is reinforced by a coat of wax, resin, or varnish, exuded by the plants. The leaves are tiny, inconspicuous, hard scales like those of our heaths and tamarisks. The whole plant presents the appearance of a dense, prickly, besom-like bush, or of a low, gnarled, brittle, thorny tree (acacias).

In places where the ground water rises near the surface, e.g. in depressions, where a well can give a permanent supply of water, or along the banks of a river, such as the Nile, the Amu-Darya, or the Euphrates, the vegetation shows at once the natural fertility of the desert soil. Palms, especially date-palms, now find congenial conditions, and, under their protection, are cultivated other food plants enough to support a small community. Gardens of this sort may be found dotted over the deserts, and often mark the course of trading routes. It is in the oases that the difference between the tropical and extra-tropical deserts is best observed. Those of the Sahara and Arabia consist of groves of date-palms, under which all tropical and sub-tropical produce are grown—rice, cotton, olive, vine, sugar-cane, millet, coffee, tobacco, oranges, and lemons. The aspect changes but little from summer to winter. The oases of the Gobi, on the other hand, are characterized by rows of tall poplars and willows. Here we find

a temperate vegetation with temperate products – wheat and barley, peach and plum trees. Egypt, Mesopotamia, the Amu- and Syr-Daryas, are so many oases due to large rivers.

In some deserts surrounded by lofty ranges the snow-fed torrents from the mountains lose themselves in the sand at no great distance from the foot of the slopes. The fans, deltas, or marshes, thus created form round the deserts a broken belt of fertile islands, along which run the trade routes. Deserts usually have wide, semi-arid margins, characterized by poor acacia-scrubs on the equatorial side, and by poor steppes on the polar side.

Except for the oases, such barren lands cannot be places of permanent habitation, but are tracts to be avoided, or crossed only when it cannot be helped. Desert animals must be swift and need little to eat and drink. Rapidity of motion is a vital condition of desert life, whether for animals or men. Only nomads can live there. Their routes are marked by the lines of wells and oases; straying far from these lines may mean death.

Deserts were not always so extensive as they now are, or else they have gradually changed their positions. The areas of many oases have also varied. The sands now yield to the patient researches of explorers the secrets of dead worlds, all trace of which seemed to have been wiped out for ever. It is clear that flourishing civilizations once developed where now nothing exists but barren wastes, and that the extension or shifting of deserts, by pushing back whole nations and setting them in motion, has determined a succession of wars and migrations which has largely shaped the history of European countries.

CHAPTER X

SUB-TROPICAL OR WARM TEMPERATE RAIN-FOREST

A FIRST impression of the warm, temperate, evergreen rain-forest may be gained by imagining an intermediate stage between the equatorial rain-forest and the most luxuriant forests that can be seen in our northern climates. The conditions favourable to their development are a warm temperate climate, with a moderate to abundant rainfall all the year round (60 to 120 inches). There may, however, be one or two relatively dry seasons. From 25 to 50 per cent. of the days of the year are rainy. The temperature remains mild throughout, with yearly averages from 50° to 70° F. Occasional frosts may occur; they are quite short and slight. With lower temperatures, less water vapour suffices to give a fairly high relative humidity, especially in winter. Prolonged dry winds, whether hot or cold, are quite exceptional.

As we go farther from the equator the importance of the nature of the soil increases. In hot moist regions the luxuriant vegetation would in course of time enrich even originally poor soils and gradually fit them for heavier crops of foliage. The soil of the sub-tropical rain-forest is fairly deep, fresh, and rich.

The combinations of circumstances required for the growth of such forests are found both in lowlands and in highlands. The map shows that they occur in lowlands in the southern states of North America from Cape Hatteras to eastern Texas, in southern Brazil and in the

higher valleys of the Paraná, Paraguay and Uruguay, in central and southern China and north-east India and Burma, along the eastern coast of Australia, in Tasmania

Fig. 24. Forest near the Iguassu Falls, Misiones, Argentina.—Large-leaved Epiphyte high up in centre. (Photo: A. W. W. Brown.)

and New Zealand, but in no part of Africa except the southernmost extremity. In highlands similar conditions are found on the slopes of equatorial mountain-ranges above 3,000 feet, in eastern Mexico and Central America, on the eastern slopes of the Andes from Columbia

to Tucuman, in Chile, in the higher mountains of equatorial Africa, in Assam, Burma, Indo-China and China, Formosa, Malayia, and southern Japan.

We may best describe this vegetation by comparing it with the typical equatorial rain-forest. In the temperate moist forests the trees are generally lower (except the eucalyptus), more spread out in the crown, stouter and more complicated in their structure, and branch lower down; they also stand farther apart. Many of them are evergreen. There is, however, a sharper distinction between the summer and winter aspects than in equatorial regions, and even an admixture of deciduous trees. The leaves are smaller, simple, oval or oblong, but somewhat thick and leathery, with a glazed upper surface and a fresher green than between the tropics; or again, finely divided like those of some acacias. Tree-ferns and small palms, bamboos, and countless shrubs and lower trees form a second tier. The enormous extent of delicate foliage of the plants indicates great atmospheric moisture. The huge leaves that were so characteristic between the tropics are not found here so abundantly, but there may be a better show of bright blossoms, e.g. in China and Japan. In New Zealand, on the other hand, the flowers are mostly inconspicuous. The spaces between the tall trees are packed with a dense undergrowth. Lianas are comparatively rare. The climbers are mostly herbaceous and in enormous profusion, 'covering the soil with a natural netting, coiling round every stem, running up every limb and gliding from head to head, entwining the topmost branches of a dozen trees in Gordian knots.' Epiphytes are abundant, though small in size and leaf. Mosses, liverworts, lichens, ferns, grasses, and orchids, cover all and pad the trunks with a soft cushion a few inches thick. Many trees bear a

strong resemblance to our northern species—camphor trees, laurels, sassafras, magnolias, camellias, beeches, and oaks. Conifers are also a feature of the landscape.

These forests are perhaps more impassable than those of the dark equatorial type on account of the tangle of

Fig. 25. Aspect of Sub-tropical Forest. Evergreen oak and festoons of Tillandsia. Florida.

shrubs and climbers above a litter of decaying vegetation. They differ from our own forests by the immensely larger size and variety of trees, the gorgeous flowers, the greater luxuriance, beauty, and variety of the foliage, and the much greater wealth of epiphytes and climbers.

In both the equatorial and the warm temperate rain-

forests, there is a regular and sufficient rainfall throughout the year and an absence of extreme cold and drought. But the yearly average amount of heat is smaller in the temperate regions. Hence growth is not so luxuriant. There is a diminution in the intensity of life. Owing to the uniformity of climatic conditions throughout the year, and to the absence of well-marked seasons and extremes of cold and drought, it is not especially necessary or advantageous for plants to shed their leaves at the same time, to flower or fruit at special periods. In other words, the lack of a strong seasonal climatic rhythm results in the lack of a definite seasonal rhythm in plant life. Hence, at all times of the year plants may be found in their green and their bare stages, in flower and in fruit. The temperate rain-forest includes many varieties ranging from sub-tropical to mild temperate types. From the hill forests of the equatorial belt to the coast forests of Carolina, or to those of New Zealand, Japan, or Chile, the main characteristics are the same, but there are important variations in the intensity of seasonal changes.

The limitation in the intensity of life and rapidity of growth is shown first of all in the reduction of the number and size of the trees. Broadly speaking, everything is reduced in scale: the leaves are smaller and less active and mobile. Species are fewer, and one begins to experience something of the feeling of sameness which is given by northern forests. The poorest types of temperate rain-forests may even consist of a comparatively limited number of species uniformly repeated over large areas. Such trees are then termed *social*.

The temperate rain-forests contain many plants of great economic and commercial importance. They yield valuable timber, especially in New Zealand and Chile. Among shrubs, tea is the most important. Numberless

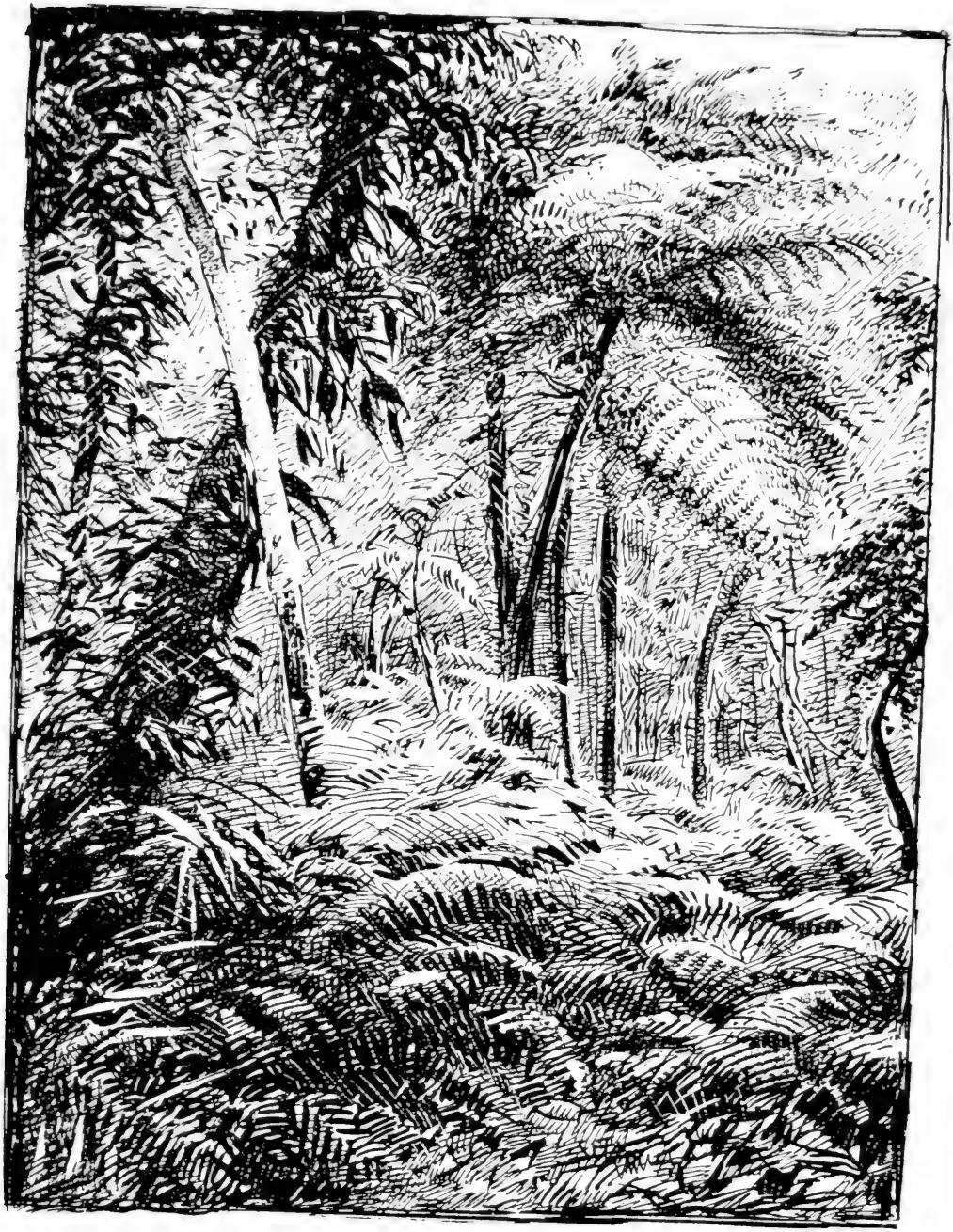

Fig. 26. Undergrowth of Hill-Forest in East Australia.

ornamental plants have been obtained from them. Kauri gum, camphor, chinchona, some kinds of rubber and gutta-percha, coca, yerba maté (or Paraguay tea) are other

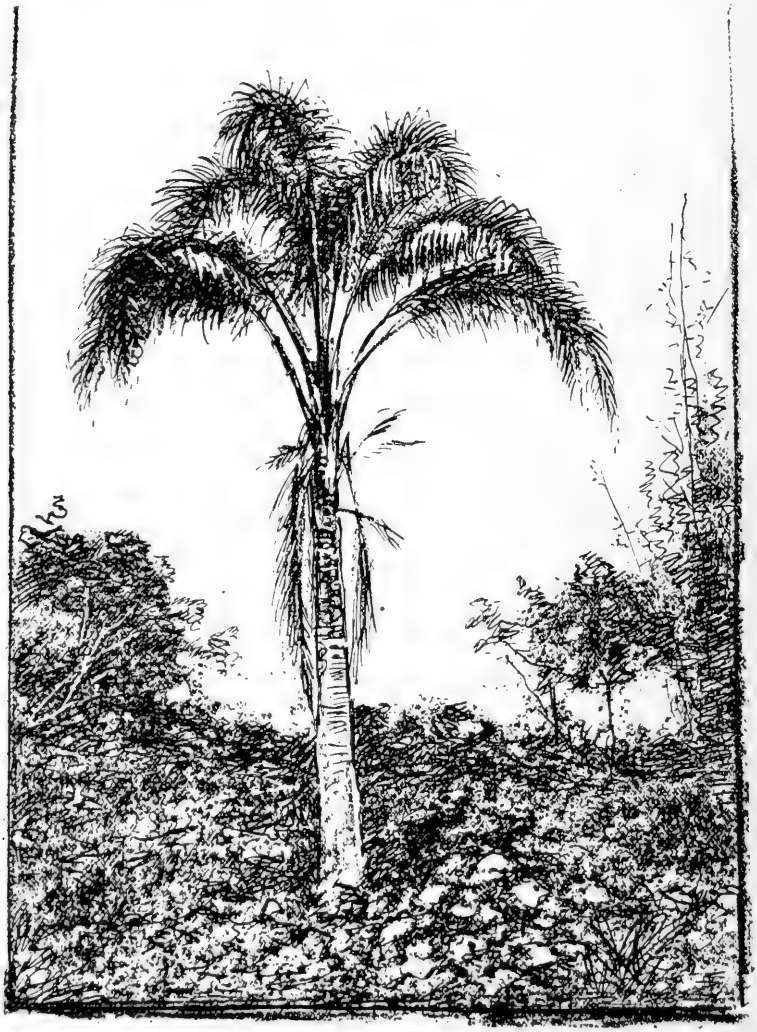

Fig. 27. Roof of Exhausted Forest or Capoeira in South Brazil. Dense tangle of the undergrowth.

valuable products. By clearing these forests, man has found an extremely rich field for sub-tropical agriculture, cultivating rice, tea, cotton, mulberries, tobacco, &c.

The warm temperate rain-forests are to a large extent free from the drawbacks of the hot rain-forests. They have been supremely favourable to human settlement, and have furnished a home for some of the most prosperous

Fig. 28. Undergrowth of Sub-tropical Rain-Forest.

and civilized agricultural nations of the world. China, Japan, and some parts of India are the best instances in the past; New Zealand, New South Wales, Chile, and the southern states of North America are instances of more modern development.

BROAD LEAVED EVERGREEN

CHAPTER XI

MEDITERRANEAN WOODLANDS

Under this name may be included the vegetation typically represented in the Mediterranean region by dry, evergreen, hard-leaf forests, woods, and shrubs. The traveller who comes from our northern moist forests receives the impression that the Mediterranean is a poor, arid country, with scattered open forests, low woods, and dense, thorny scrubs. He misses the fresh green foliage and the rich, grassy swards. The strong colour contrasts are apt to offend his eye. If, however, his visit be in early spring he will find the land robed in fresh verdure and bright flowers. For the native, the exhilarating beauty of spring, the serene and balmy autumn, and the mild winter redeem the dry and scorching summer.

The climate and vegetation of the shores of the Mediterranean are represented, north of the desert belt, in California. South of the austral arid belt they find equivalents in the south-west of South Africa, in south-western Australia, and in the valley of central Chile.

The climate may be generally described as warm temperate, with a mild, rainy winter and a hot, dry summer. The average temperature of the year differs little from that of the temperate rain-forest lands, 50° to 70° F., but it has a much greater range, both daily and seasonal. Snow and ice are not infrequent in mid-

Fig. 29. Cypress, Pine, and Evergreen Oak Woodland in South of France. Garigues in the distance.
(Photo : J. Lagarde.)

winter. The rainfall is smaller than that of the temperate rain-forests; it is irregular, and varies from 20 to 40 inches. The bulk of the rain falls during the short winter in heavy showers, and the dry summer is broken only by occasional storms. The quantity of moisture in the atmosphere also fluctuates greatly.

The nature of the mediterranean lands is varied. Broad, sandy flats, rich alluvial plains, marshes, downs, rocky scarps, hill-lands and mountains afford many dissimilar conditions for vegetation; so there is much diversity in the plant landscapes. The most important of these are: (1) scattered and open woodlands of evergreen oaks—stout trees with low, rounded, heavy and sombre crowns. Among such woods are found a large variety of evergreen, hard- and small-leaf, dull bluish shrubs and trees of which laurustinus, oleander, myrtle, and rosemary may be taken as examples, in addition to laurel, olive, carob, orange, terebinth, and fig-trees. (2) Higher and more regular but similar forests are formed of the valuable cork-oak. (3) Groves of olive and fig-trees, although mostly cultivated, occur also in the wild state, with a very mixed hard-leaf vegetation. (4) Varied forests of conifers —pines, firs, cedars, cypresses, and junipers—occur. Some have bare floors or heath or dry, stiff grass brushes; some have dense undergrowths of evergreen, hard- and small-leaf, often prickly and sticky shrubs. They are especially common in hill- and mountain-lands, and are most abundant in the Pacific mountains of North America. (5) Areas with sufficient moisture in the ground are often covered with light forests of deciduous oaks and other trees, resembling, but not identical with, our northern oak forests. (6) Where the forest has been destroyed and the land left uncultivated a dense scrub springs up, 6 to 10 feet high, of mixed deciduous and evergreen

bushes, called maquis or macchia, of which there are several types. It is made up of small trees, shrubs and undershrubs, creepers and vines, similar to those of the undergrowth of the destroyed woods. (7) Limestone hills, scarps, and tables, with scattered thickets of stunted, bushy, prickly evergreens, showing the naked rock between them, are called in France 'garigues'.

Fig. 30. Rock Pine in Spain.

(8) Extensive wastes, more especially on the southern side of the Mediterranean, are covered by dwarf palm bushes, which in spreading 'seem to crush out all other vegetation. The rosettes of fan-shaped leaves, only a few feet high, appear to rise out of the ground itself.'

It will help to emphasize the contrast between the mediterranean plant life and that of the equally warm temperate rain-forest, if we term the former a dry evergreen type, and the latter a wet evergreen type, of

the warm-temperate vegetation. The wet evergreen form is due to active growth throughout the year, which is made possible by an abundance of warmth and water at all seasons. The dry evergreen form is due to a continuous but slow growth throughout the year. This may seem in contradiction to the marked seasonal rhythm of the climate. In the Mediterranean, however, no season is sufficiently unfavourable to render plant life entirely dormant. Winter is mild; summer is dry but not absolutely rainless. On the other hand, except during the two short spells of early spring and late autumn, no season is sufficiently favourable to encourage intensely active growth. When the rainfall is satisfactory, the temperature is rather low; but when warmth is sufficient, water is scarce. The hard, evergreen leaf is adapted to such a life. Its compact structure, though not suited for intense activity, permits it to survive short spells of extreme cold or drought. To prevent excessive loss of water through the leaves during the dry season, the total surface of foliage is reduced by the leaves being fewer and smaller. The proportion of wood to leaf seems great. For this and other reasons, the whole appearance of the mediterranean vegetation is compact and woody. The wood is protected by a thick, rough bark of which cork is the type. There are many other protective devices against excessive perspiration.

Conifers, most of which are evergreen and provided with needles or scaly leaves, are well represented in mediterranean floras. They are the chief trees of the regions of western North America with a mediterranean climate. The similar regions of South Africa, south-western Australia, New Zealand, and Chile have small-leaf trees, but only few conifers.

The same steady, thrifty life characterizes the shrubs,

FIG. 31. Maquis in South of France. (Photo: J. Lagarde.)

undershrubs, and herbs of the lower layers of the vegetation. In all of them protective, woody, and fibrous tissues, and small and hard persistent leaves are developed. Most herbs have the form of shrub-like perennials.

As in all lands where water is scarce, a wealth of underground bulbs and tubers is one of the features of the Mediterranean; indeed, it is one of its glories. Asphodels, irises, orchids, anemones, tulips, arums, muscaris, narcissi, onions, gladioli, and leucoiums are some of the most familiar. Other forms store water above ground, such as aloes, agaves, and even cacti, which though not indigenous, do remarkably well. Palms, which flourish best in warmer lands, reach their poleward limit and smallest size here.

In such regions the quantity and distribution of ground water becomes of paramount importance. Consequently the nature of the soil and subsoil determines the appearance of the vegetation, as well as its economic value. Irrigation is often necessary. Where it is practised the agricultural resources are very varied owing to the great differences between the seasons. The cultivation of northern cereals is possible in the mild season. On the other hand, the cultivation of sub-tropical and even tropical produce, e.g. rice, cotton, maize, and hard varieties of wheat, is possible in the hot summer. Fruits in amazing variety flourish in addition to those with which we are familiar in northern countries. Olive, orange, fig, almond, peach, plum, grape, and pomegranate are a few which may be mentioned. Early flowers, fruits, and vegetables are produced for the northern markets. Indeed, the mediterranean region has an extraordinary number of food-, industrial, and ornamental plants. Among these are the carob or locust-

Fig. 32. Big Tree Forests in Sierra Nevada, California.

bean, grape-vine, tobacco, cork-oak, water-melon, roses, and other aromatic plants, bulbs, ornamental shrubs and perennials, fodder, winter-grazing, and even timber. From earliest times the Mediterranean has been the mother of great civilizations. Whilst the heart of Asia was acting as a pole of repulsion, the Mediterranean acted as a pole of attraction. Through the conflicts of races and civilizations its shores were repeatedly laid waste, and its natural wealth temporarily somewhat exhausted. But no other vegetation has exercised a greater influence in the history of mankind.

CHAPTER XII

OTHER EVERGREEN FORESTS

THERE are other important types of evergreen forests, the conditions of which are intermediate between those of the Mediterranean and those of sub-tropical dry lands:

The **Eucalyptus Forests** of southern and eastern Australia form a sort of park landscape in which the continuity of the forest is frequently broken by grassy glades. The gigantic eucalyptus, with light and patchy crowns and a bark hanging in ragged strips, grow scattered on a floor of dry grass. Their drooping, sabre-shaped leaves, always turning edgewise towards the sun, do not afford any shade. When acacias are absent, the under-

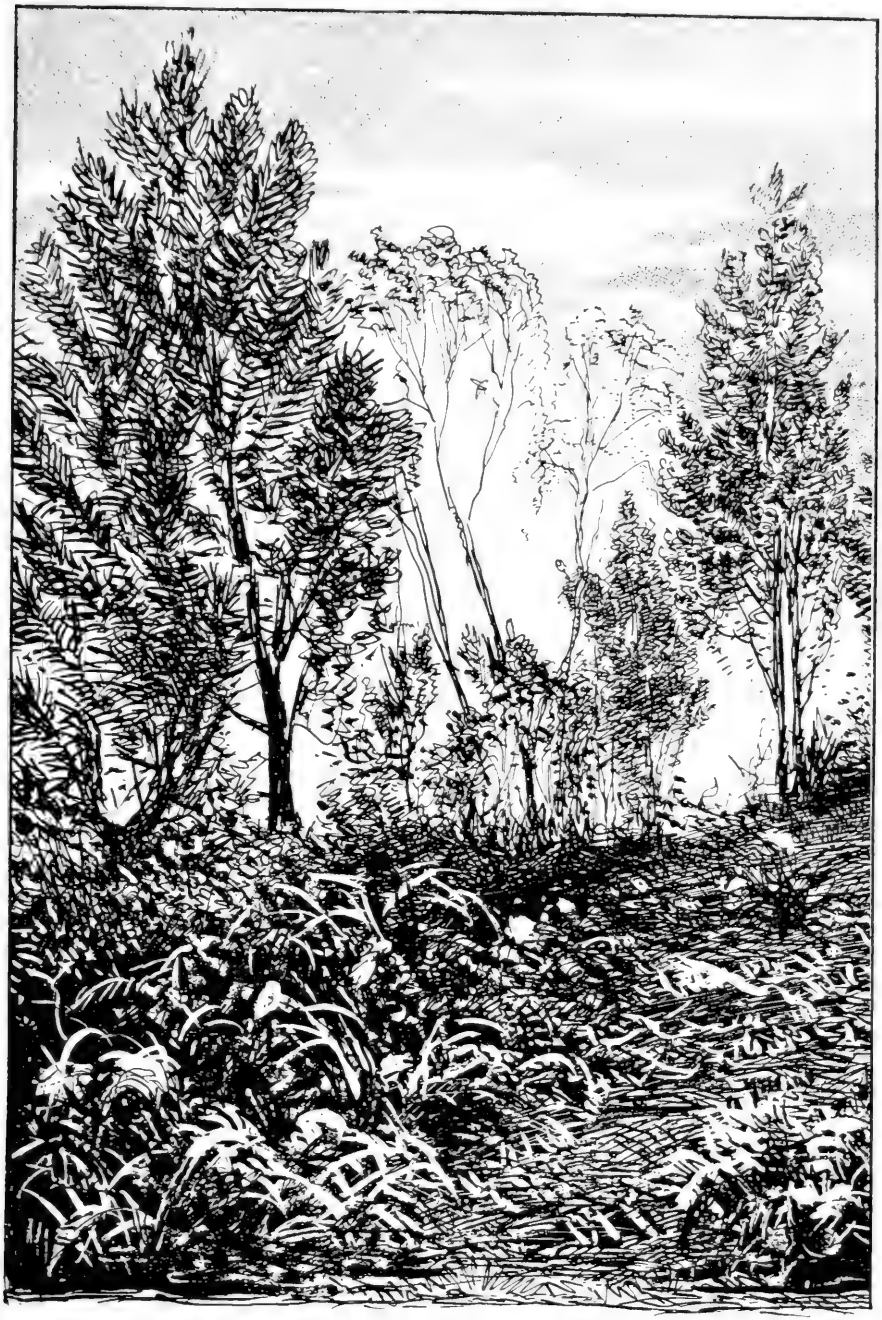

FIG. 33. Silver Tree, Evergreen Shrubs and Bulbs. Cape of Good Hope.

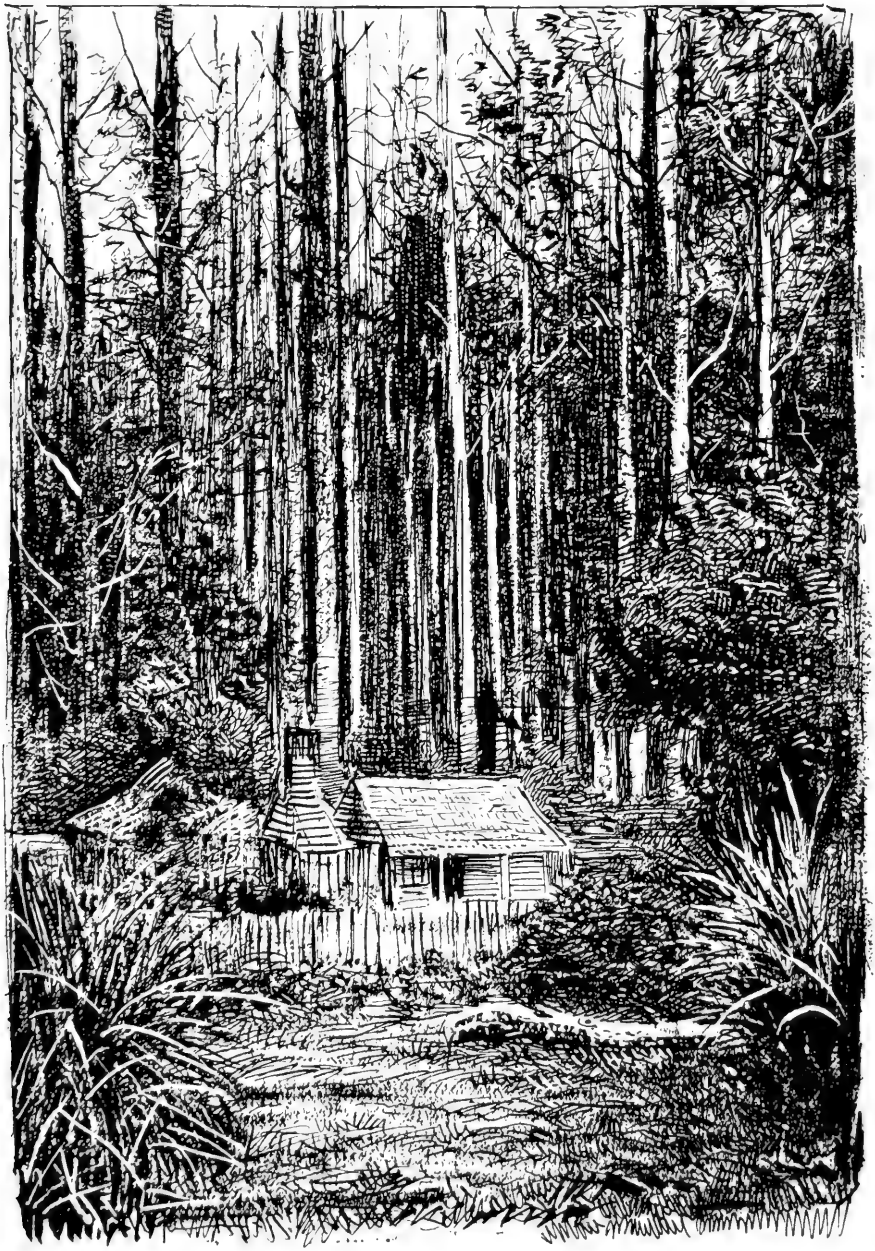

Fig. 31. Dense Eucalyptus Forest in East Australia.

wood is usually very meagre; the interior of the forest remains quite sunny and open.

Araucaria Forests on the table-lands of southern Brazil, though very different in appearance from the eucalyptus forests, agree with them in many of their characteristics and have a similar type of life. In

Fig. 35. Araucaria Forest in Misiones, Argentina.

these, the straight and slender trunks of the monkey-puzzle trees bear on their tops flat crowns of horizontal branches. Their leaves are scarcely more than short, hard, thick, needle-pointed scales. The araucarias grow in loose clumps, often intersected by grassy glades or campos. Their undergrowth is varied, consisting here of a short grass sward, there of thickets of the ever-

Fig. 36 Park Landscape or Savana Woods in Australia.

green Yerba Maté or Paraguayan tea, and other shrubs.

In the South American Chaco extensive **Quebracho Forests** make a transition from the swamps of the Paraguay River to a more arid region in the rear. These forests are also evergreen. The Quebracho trees have a gnarly, bushy growth, and very light crowns. The leaves are so tiny and inconspicuous that the trees look as if they were bare. The heavy undergrowth is an impassable thicket of tall, hard-leaved, evergreen shrubs. Here again the woods alternate with tracts of grass-land, forming a park-like landscape graced by palm groves.

These various types of evergreen forests in sub-tropical lands have sometimes been called **savana-forests,** because they are intimately associated with grass-lands. The excellent quality of their timber, gum, and other products has made them very useful.

CHAPTER XIII

TEMPERATE SCRUBS

THE foregoing brief account of the evergreen vegetation of the mediterranean countries will make it easier to understand how an even greater dryness of climate leads to the disappearance of trees and the predominance of shrubs. Such conditions are found in the Australian *scrub* and the Californian *chaparral.* It is difficult to say how far the absence of trees is due

to man in a great many cases, especially in California. We have seen how, in the Mediterranean, the sheep, the axe and torch of man, have extended the maquis. There, however, if left alone for a sufficient time, the forest will be regenerated. The maquis is, in fact, often a preparation for the forest. But when the climate and the soil are drier or have been permanently injured and impoverished by the destruction of the timber, it is quite possible that it takes hundreds of years to form anew a fit soil, and that in the meantime the scrub remains the exclusive master of the ground. Such seems to be the case in many parts of California.

The relative permanence of the scrub thus adjusted to its environment, its unique, well-defined appearance, the probability of its spontaneous origin in most places, and its wide distribution, all make it desirable to recognize it as an independent and characteristic formation. In Australia it is one of the dreariest and most dreaded landscapes. A traveller says: 'The monotonous and dismal look of an extensive scrub is depressing, especially when viewed from an eminence; the equal height of the vegetation, the dull glaucous colour of the foliage, look in the distance like a rolling sea reaching the horizon—at least the first sight of the Murray scrub, extending hundreds of miles, produced this impression on my mind.' Every one avoids the scrub as much as possible; many have lost their way there and perished for want of water. All the different scrubs produce a similar impression, but the plants comprising them are not of the same genera and species. Locality and soil affect the character of the flora.

Shrubs of one kind or another are found in flower, in the scrub, throughout the year. The majority, however, blossom in early spring, but the rainy season alters the

Fig. 37. Scrub or Chaparral in California.

appearance of the vegetation very little, though it calls into life numerous terrestrial orchids and other bulbs. The scrub is a closely packed, prickly, sticky, scented tangle of dull shrubs, without trees or grass, and destitute of water, under a fierce sun, and a singularly clear atmosphere. It is evergreen, and is composed chiefly of bushy plants, with stiff, dry, simple, entire leaves, which are

Fig. 38. Mallee-scrub.

arranged obliquely to, or even parallel with, the light, and possess a dull bluish surface, often due to a coating of wax or resin.

Several kinds of scrub are found in Australia. There is the *Mallee-scrub*, an impassable tangle of bushy eucalyptus, in dense shrubs, 6 to 10 feet high, which send directly from the soil bundles of long, thin shoots ending in bunches of hard foliage. The shrubs are all

uniform in height and colour. Few other forms are admitted, and these possess mostly heath-like or vertical leaves. Grass is entirely lacking.

In the *Brigalow-scrub* two or three kinds of acacias are predominant, with sickle-like leaves and a shimmering silver-grey colour. Round these the other humbler plants are gathered in impenetrable thickets.

The *Mulga-scrub*, also composed of thorny acacias, is generally more open and possesses a ragged carpet of dry grass.

The *Californian chaparral* is very like the Mediterranean maquis. It is stocked with evergreen and deciduous shrubs forming a continuous cover. Dwarf oaks, mezquites, composites, rosaceous and leguminous plants are common.

In many cases it is difficult to bring these scrubs under cultivation and even to utilize them in any way. Climate and soil, alike, are unfavourable to pastures or to agriculture. They are avoided, for they offer great obstacles to communication.

CHAPTER XIV

SAGE BRUSH

Passing now to a still more extreme case of dry extra-tropical climate where there are only occasional showers, we find a type of vegetation which in western North America has received the name of *sage brush*. It

resembles an arid heath or a semi-desert, and is frequently so described by travellers. The climate is dry and warm, but has sudden and sharp contrasts of heat and cold. The mean average temperature for the year ranges from 50° to 65° F. There is a brief vegetative season of two to three months, with short, heavy showers or fine, drizzly, irregular rains.

Sage brush soils are extremely varied, but are seldom rocky. Thanks to the dry climate they often become impregnated with alkali salts, as in true deserts.

Such general conditions occur on the high plateaus of Asia Minor, in belts round the deserts of Central Asia and Australia, in the Great Basin of North America, and as far south as central Mexico; south of the Pampa, in Patagonia, in South-west Africa (Kalahari and Karroo), in North Africa, north of the Sahara, and north of Arabia. Thus the sage brush is much more widely distributed than the scrub and chaparral in extra-tropical countries.

The sage brush region is generally a vast, undulating or flat expanse. The bare soil is covered with hoary or dull-grey, sticky, scented, sage- or heath-like shrubs, 3 to 6 feet high. These may grow densely in a grey sea of woolly bushes, or be scattered over otherwise naked tracts. In some countries the pale, blue-green pillar of some solitary cactus plant may rise out of the dull brush. No leafy trees, no green grassy swards break the monotony of the landscape. Some variety is afforded by the networks of waterless stream-beds, marked by a taller and fresher growth; by salt lagoons, dry most of the year, but at times forming vast, shallow sheets of water (such hollows are surrounded with belts of dwarf, fleshy, pale green shrubs called succulents or salt-bushes); or by bare tracts of soil powdered over

with whitish flakes of alkaline salts. Sometimes the dwarf shrubs are replaced by stiff bunches of wiry, fibrous grass, such as esparto; at other places the landscape is formed of a scattered, but regular, heath with taller, lanky bushes.

The *shrubby perennials*, which compose the sage brush, are besom-like in appearance. They rest on thick, woody

Fig. 39. Sage brush, Semi-Desert. Rio Mancos Valley, north side looking west. (Photo: A. W. W. Brown.)

stumps, sending down a number of cord-like, fibrous taproots to great depths. The leaves are usually less than one inch long, narrow, leathery, stiff, and rolled inwards. They are covered with a dense down of glandular hairs which give them a whitish-grey tint, or coated over with resin, gum, or wax. They stand mostly erect, seldom flat or spread, but compressed against the stems or at an angle with them. Few of these plants display large

and bright flowers. Many have large bunches or heads of small flowerets, while others possess whitish, woolly, inconspicuous inflorescences. There is no sharp contrast between the appearance of the vegetation in the rainy and dry seasons, because the distinction between these periods is not well marked. In addition to the shrubby perennials a multitude of seeds lie in the soil and burst into small, short-lived plants when rains are prolonged enough. By reason of their relatively low position, in vast hollows and on the margin of deserts, a certain amount of ground-water is within reach of the plants, but the supply is scanty. The evergreen, shrubby perennials depend on it entirely; hence a slow but continuous, almost dormant kind of life, throughout the year. The subsidiary and ephemeral vegetation depends on rain, which is generally under 15 inches per annum. On the whole, this is a combination of conditions not entirely unfavourable to hardy plants, but leaving them constantly on the verge of drought.

Another class of plants adjusted to such an environment is that of the cacti, aloes, agaves, and similar forms, which contain large stores of water. Usually they have no leaves, or when leaves are present they are so thick that they form reservoirs.

If the climatic circumstances of the sage brush regions are unfavourable to plant life, their soil is not. Indeed, it is often very fertile. When reclaimed by irrigation many such regions are transformed into rich farmlands. Oases have been created in the barrens east and west of the Rocky Mountains and in Arizona. In the last century the sage barrens were the scene of an admirable instance of dauntless courage and pertinacity, when those industrious colonists transformed the sage tracts of Utah into a flourishing oasis, capable of supporting a dense

population. A special method of agriculture based on the preservation and economical use of the surface moisture has been devised and applied with success in those regions. Thanks to this *dry-farming*, what looked like waste sands have been made to yield paying crops of maize and lucerne.

Fig. 40. Sage brush. North Colorado.
(Photo: A. W. W. Brown.)

Nor is the sage brush wholly devoid of natural resources. In Mexico, for instance, the sage-like *guayule* has yielded enough rubber to call into existence a small industry in the desert. But these are only recent and solitary developments. Except for oases which may be found in Africa, Asia Minor, and Central Asia, most of the sage brush lands are areas which have hitherto not only received no attention but have been avoided.

CHAPTER XV

STEPPE, PRAIRIE, PAMPA, VELD

The steppe is the dry grass-land of the temperate countries. This form of vegetation covers vast areas, chiefly in the heart of the continents, outside the tropical belt. Thus it occupies the central part of the North American lowlands and a large part of Argentina. It extends over the South African plateau as far north as the tropic of Capricorn. In Eurasia it stretches between the northern Siberian forest on the north and the central deserts on the south, from Manchuria and Korea to southern Russia and even covers parts of Bulgaria and Romania, while outliers of decreasing importance are to be found in the Hungarian Puszta, in Italy and in Spain.

The Asiatic steppe extends like a 'vast floor, all green, with a dash of yellow flowers here and there, while beds of wormwood in silvery white glisten like a silken tapestry or a delicate gauze. . . . The scenery is uniform: a sea of grass, swelling undulations, to paint the ridges of which Nature has exhausted all the greens of her palette. The troughs are lined with bright yellow masses of buttercups. In the height of summer the steppe is carpeted with straw. It is then a dreary and lifeless immensity, no longer relieved by brilliantly coloured flowers.'

The steppe climate is characterized by a severe and dry winter, a mild and moist early summer, with

Fig. 41. Canadian Prairie. Saskatchewan River, Fort Pitt. (Photo : C. W. Mathers.)

frequent showers, and a hot and dry late summer and autumn. The rainfall is scanty, ranging from 14 to 24 inches with an average rarely exceeding 20 inches. Each year has about 100 rainy days. The atmosphere is dry, especially in winter when strong, icy winds sweep across the plains.

Steppe regions, the soil of which commonly consists of very fine loam, loess, clay, or sandy clay, as a rule, have a flat or slightly rolling aspect, always very uniform. On the American prairie, 'One may ride for many miles without seeing any distinguishable eminence to interrupt the uniformity of the plain, which extends to the horizon in all directions. There are no trees, no shrubs . . . , no tall herbs.'

The vegetation, though varying in detail, is also exceedingly uniform. It consists of a low, close, continuous, treeless sward. Compared with our meadows and pastures the steppe grass is dry, bluish-green in the growing season, straw-yellow later on, brown, grey, or dark for the rest of the year. Among the different aspects which this steppe assumes may be mentioned (1) the continuous, short, dusty-green turf entirely formed by buffalo-grass; (2) the wavy, subdued silver-white, feather-grass carpet of the Black Sea region, resembling rippling water; (3) a brighter and more varied mixture of plants in the hollows of the same region; (4) the sea of grass may be sprinkled with short, woody undershrubs and herbs of varied species, or again invaded by creeping prickly-pears and cacti. (5) In the Argentine Pampa the grass grows in separate big tufts, between which the bare soil may be seen.

The appearance of the vegetation varies with the season. In early spring, numerous bulbs and short annuals diversify the carpet of tender green. In late

spring and early summer most grasses and taller annuals come into flower; this is the season of greatest luxuriance. Later on, nothing is left but dried stalks and parched tufts. In autumn, however, another grey, woolly, higher and drier vegetation may spring up, which makes the steppe look for the time being like a short, dense sage brush.

The steppe grass is of a drier, hardier nature than our meadow grass. This is seen in the narrower, stiffer

Fig. 42. North American Prairie Grass.

leaves, which are more fibrous, less juicy, and tougher for grazing purposes. They point upwards and roll up lengthwise or curl inwards. The tufts are dense, compact cushions made up of bundles of dried-up sheaths, the remnants of the previous years' growth out of which the new shoots arise. These tufts are seated on stools of short, superficial, highly ramified roots. When the plants are closely packed their roots become entangled and form a dense, elastic felt, which acts as a sort of sponge.

Other steppe plants are perennials and undershrubs, bulbs and tubers. All these are comparatively small, seldom more than 2 feet in height. This is partly due to the shortness of their vegetative period. Evergreen perennial shrubs and undershrubs have small, leathery leaves, with protective coatings and air-containing hairs.

The variety and abundance of bulbs is one of the chief features of the steppe, as of all dry countries. They are able to survive the extreme winters and summers by means of their underground store of water and food. They burst into a very intense, if temporary, growth during the mild and rainy spring, when they replenish their reservoirs. During the remainder of the year the parts above ground die and those underground elaborate the food materials and utilize them in propagating.

The growth of trees and shrubs is prevented in the steppe regions by several hostile circumstances, the most important being the scarcity of water. A yearly average rainfall of 20 inches seems to be necessary for tree growth in the cool temperate regions, and steppes generally have less than this. Neither deciduous nor evergreen trees can stand extreme winters, when strong and dry winds blow over a frost-bound soil, as is the case with most steppe lands. In some places, in addition to these unfavourable climatic conditions, the soil is too fine and compact and therefore dry and airless. The growth of a close mat of tiny and tangled rootlets, covering the soil with a sort of impervious felt and further depriving it of air and water, is another factor inimical to the development of trees and shrubs with their deeper-seated roots. Along the margins of the steppe there is a struggle between grass

and trees, each taking advantage of the slightest variation of the soil in its favour.

The grass-land of the steppes supports large herds of wild and domesticated horses, cattle, and sheep. On

Fig. 43. Manchurian Steppe and its Dwellers.
(Photo : Donaldson Smith.)

the other hand the scarcity and irregularity of rainfall renders agriculture very precarious. Hence the development of pastoral industries and modes of life. Since the grass dries up periodically, and cattle have

to move to other pastures, steppe dwellers must lead a nomadic existence. The horse and camel are indispensable means of conveyance and transport. Under such conditions the population of these grass-lands remains scarce and primitive. Steppe soils, however, are not necessarily poor; indeed they are mostly rich, and with the help of irrigation such crops as wheat, barley, maize, and beetroot can be grown to perfection. In recent years agriculture and industries have developed on the Russian steppes, favoured by an exceedingly rich soil, the black earth or chernoziom. Similarly in Canada, the United States, and Argentina, large tracts of prairie ground have been turned into prosperous granaries, and bid fair to become the wealthiest wheat districts of the world.

CHAPTER XVI

TEMPERATE DECIDUOUS FORESTS

THE cool temperate deciduous forest is the predominant feature of our northern countries, except on the higher hills.

Though we now see only patches of it around us, this forest once covered the greater part of central and western Europe, north of the Alps and Pyrenees. It extends eastward across Russia in a belt which is wedged in between the northern resinous forests and the southern steppe, and gradually dies out towards

the Urals. In eastern Asia it reappears under a similar climate in the Amur region and in Japan. In North America it has its greatest development on both sides of the Appalachians, westward beyond the Mississippi and northward to the lake region. In the southern hemisphere this type of forest occurs in small stretches in Patagonia, southern Chile, and Tierra del Fuego. It is nearly absent from Africa and Australia.

The temperate, summer-green forest is composed of those oaks, beeches, ashes, maples, birches, rowans, aspens, elms, lime-trees, and others with which we are so familiar. There are, however, various types, the most important of which may be noted.

(1) The tall, sombre beech forests form a uniform and close canopy of heavy, globular crowns, intercepting the light almost completely, and forming underneath a dark vault supported by tall, slender trunks. Few competitors are admitted among the beeches. The trees are crowded together, shutting out smaller and lighter species.

In the interior of the forest few shrubs and herbs can withstand the semi-darkness, and these are all lank and weak-looking, with few drawn-out twigs. A brown mat of leaves and mould covers the ground. It is only during the short early spring before the leaves appear on the beech-trees that a number of plants find an opportunity of putting forth bright flowers. At that season primroses, wood hyacinths, wood sorrels, white anemones, and others make a most beautiful carpet under the bare branches. Such forests are found in England, as well as in many parts of western and central Europe. They are even more beautiful among the Alps and on the higher slopes of the south European mountains. The highlands of eastern Europe

still shelter some luxuriant forests of beech and mixed conifers, which, though varying in detail from our own beech vegetation, display a similar appearance and mode of life.

(2) The oak forest is more open, lighter, and smaller, more varied and irregular, for oak trees require more light and space for their crowns and roots, and the sunshine can penetrate through the intervening spaces. Along with oak we may find ash, birch, maple, aspen, rowan, poplar, elm, and pine, according to the nature of the ground. Smaller trees and shrubs, such as holly, juniper, alder, hazel, hawthorn, wild cherry, logwood, &c., flourish in the comparatively slight shade. A large number of undershrubs, herbs, and grasses, such as foxglove, willow-herb, ferns, &c., are found in a still lower layer. Small creepers, mosses, and lichens grow on the trees.

The plains of the Danube basin possess a species of oaks and other summer-green trees unknown in western Europe, but in spite of such differences, these forests are most nearly related to the West-European oak forests.

(3) A third variety of deciduous vegetation occurs on marshy grounds liable to inundation. Here a closer and more tangled mass of such trees as willows, poplars, aspens, alders, birches, is interspersed with saplings of the same kinds, and other shrubs clad with creepers, clematis, honeysuckle, mosses, and ferns; while tufts of tall grass, ferns, and other herbs flourish on the moist ground.

(4) The mixed summer-green forest is still more varied and luxuriant in North America, as well as on the southern shore of the Caspian and Black Seas, on the eastern slopes of the Tibetan plateau, and in

FIG. 44. Summer-Green Forest. South Appalachians, North Carolina.

Japan. Numerous kinds of oaks, beeches, walnuts, hickories, maples, aspens, poplars, tulip trees, magnolias, and other trees are mixed with equally numerous and varied kinds of pines, cedars, spruces, and allied conifers. The undergrowth is luxuriant, and contains rhododendrons, azaleas, magnolias, fuchsias, kalmias, and others with gorgeous flowers. Creepers with beautiful foliage and herbs are abundant. This last formation is a link between the northern summer-green forests of our countries and the temperate rain-forests.

(5) The sweet-chestnut forests which grow on granite and other siliceous soils on the southern slopes of the Central Plateau of France and of the mountains of southern and eastern Europe form another type. They consist of stately trees with short and stout trunks, heavy crowns, and broad, long leaves. The undergrowth, though variable according to soil and position, is of the ordinary northern mountain type in which ferns and grasses predominate.

(6) A drier, lower, and thinner kind of woodland, in which hornbeam, elm, lime, hazel, blackthorn, roses, brambles, and juniper play a conspicuous part, with dry grasses, characterizes the hilly limestone districts of central Europe. This landscape might be appropriately termed a temperate park-like woodland.

In spite of their minor differences all these forests have a cool-temperate, moist climate, with rain all the year round, and a fairly severe winter. The comparatively low temperature averages 46° to 54° F., with extremes in winter and summer. The yearly rainfall varies from 28 to 60 inches. The winds are moderate. There is a sufficient amount of atmospheric moisture and ground-water throughout the year. This is very suitable for the growth of trees and also of grasses. The struggle

between the two is controlled by the humidity and the nature of the soil, the altitude above sea-level, and, last but not least, by man's intervention.

Compared with evergreen tropical or even with temperate rain-forests, our northern forests show the

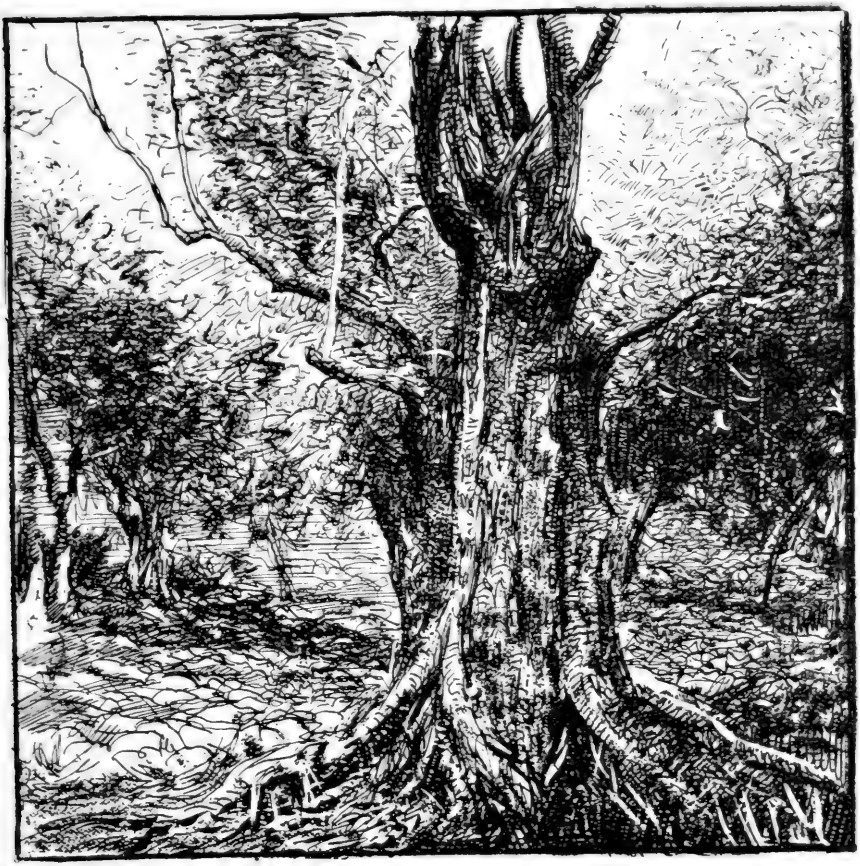

Fig. 45. Sweet Chestnut Forest in Cevennes, France.

effect of the much shorter vegetative period and the less favourable temperature conditions. They have a slower life and growth, resulting in a shorter stature and diminished luxuriance, a foliage reduced both in variety and in size, fewer and smaller creepers and epiphytes,

and a poorer undergrowth. The trees form a great quantity of wood, for wood is one of the reservoirs of plant food and water during the cold season.

A strong seasonal rhythm is the chief feature of these northern climates, the most conspicuous result of which is the alternation of the winter and summer aspects of the vegetation. Plants generally have their resting

Fig. 46. Summer Forest and Park Landscape in Sakhalin.

or sleeping period in winter, but they do not all show it in the same way. Many of them, the so-called *annuals*, take their rest in the seed stage; all the other parts of the plants die at the close of the season of growth each year. In the case of the *perennials*, certain parts, and at least the underground organs, persist during the resting season; they do not grow, but lead a dormant life. Recurring frosts and a heavy evaporation due to the strong winds which occur in our latitudes in winter, often coupled with ice-bound and, therefore, dry soils, soon kill the broad and thin leaves of the taller trees and shrubs. Trees that shed

their foliage before winter are therefore suited to our climate. This produces in its turn a marked periodicity in the lower layers of the forest. Most forest plants produce their leaves and flowers before the leaves of the trees above them cut off much light. Hence the flowering and most active period of forest life begins on the ground and gradually spreads upwards to the trees. Outside and inside the forests the rhythm of the seasons is marked by a succession of plants, displaying a regular pageant throughout the year and forming a climatic calendar.

Owing to the scanty variety of trees and shrubs our summer-green woods consist essentially of social trees. Hard-wood and soft-wood timbers are the chief economic products. With the exception of a few fruit-bearing bushes, food plants of any importance are absent. The forest dwellers, however, manage to find in them an incredible variety of resources, for their houses, furniture, clothing, food, and even medicine, though only on a small scale.

It should be remembered that the climate and soil which encourage the growth of such forests also favoured the development of the most prosperous agriculture and grazing, and of the highest stages of civilization yet reached by mankind.

CHAPTER XVII

THE TAÏGA

The taïga, or northern coniferous forest (also called the sub-arctic forest), is one of the most widespread vegetations on the globe. It covers almost uninterruptedly the north of the great continents of America and Eurasia. In Asia, its southern limit oscillates about 55° N.; in north-western Europe, this limit is about 60°; in North America, it is found farther south, and reaches to 45° in the east. The taïga is bounded to the north by the tundra.

The taïga is composed of pines, firs, spruces, larches, and allied species, intermingled here and there with various kinds of birches, aspen, and a few other leafy trees. In most cases, it forms a lighter kind of vegetation than the forest of broad-leaf, summer-green trees. Its cover, except for the spruce, is fairly light, there being only small differences between the winter and the summer aspects of the tree crowns.

A similar coniferous forest is found in nearly all mountain districts below the upper timber limit and above the belt of broad-leaf forests. This is generally called the sub-alpine forest, from its development among the Alps.

The climate of the taïga is decidedly cold and moist. The yearly average temperature is 39° to 46° F., with possible extremes from −58° to +122° F.; so there may be extreme cold in winter and very great heat in summer. The rainfall is moderate, generally more so

Fig. 47. Portage in North Canadian Spruce Forest. Mackenzie River. (Photo: C. W. Mathers.)

than further south, and fairly regular throughout the year. Winds are not so strong as either in the arctic zone or over the steppe belt. The soil is generally poor and of glacial origin, sandy, clayey, or pebbly.

Some aspects of the taïga may be briefly mentioned here: there are light pine forests on drier, sandier soils and rocks; dark and heavy spruce forests on moister and marshy grounds; fir forests; larch forests on deep, well-aerated soils; mixed forests of these species, in addition to birch and aspen; scattered forests as in northern Canada, formerly another sort of park-like landscape; the swampy taïga, intersected by marshes which are overgrown with rushes and reeds or by mossy bogs. The ground vegetation consists of a few ferns, crawling undershrubs, and stunted bushes, such as bilberry, heather, bearberry, cranberry, winter-greens, crowberries, and of dwarf birch, dwarf rose, grasses, lichens, mosses, &c. This undergrowth seldom constitutes a close sward, and is often extremely scattered, especially under the heavier trees like spruce and fir.

As one advances northward the forest grows more stunted and scattered. Trees of great age remain thin, low and gnarled, more and more branched and bushy in aspect. The proportion of wood increases and the bark has a rougher and thicker structure. There is more and more dead wood, and trees and branches are often covered with moss and lichen.

A fairly sharp line can be drawn at the northern limit where the forest is replaced by moors and pastures, and only clumps of trees are found standing like islands in the middle of the tundra. These outposts, exposed to the fury of the winds, look very desolate. Their trees remain scattered, stunted and gnarled, and sometimes crawl. Half of them are dead, and the ground is encum-

Fig. 48. Near the Limits of Russian Taïga.

bered with dead wood. In Canada and Alaska the most northern part of the taïga is a plain with thinly scattered trees. Only the banks of streams have a continuous belt. A narrow fringe of stunted, bushy birch, beyond the coniferous taïga, forms the polar limit of trees.

To withstand the severe climate trees must be well protected against wind and cold, be very frugal in their demands on both soil and climate, lead a slow life, and store in their tissues an abundance of food materials. The hardy northern conifers fulfil these requirements. Their most active and delicate parts are reduced to a minimum in the short, needle-shaped leaves, which are generally rolled lengthwise, and have a thick, leathery skin and a compact, fibrous structure, affording but little grip to the wind. Notwithstanding the number of these needles, the total green surface is limited. In short, the foliage is effectually protected against drought.

The whole structure of the conifers is interesting as an adjustment to the prevailing conditions. The conical shape of the trunks, with broad bases and tapering tops, makes the trees stable even in strong winds. This stability is increased by the remarkably short development of branches; only when the top shoot has been destroyed do the side branches approach the size of those of our broad-leaved trees. The great proportion of wood to leaves is striking, and this wood stores an abundance of reserve food in the form of starch in its tissues. Indeed these conifers may be regarded as large stores of food with growing tops which are not very active. They spend little, earn little, and hoard much; they lead a slow, thrifty kind of life, well adjusted to the circumstances in which they are generally placed: a spell of bad weather in the growing season would mean disaster to a more luxuriant type of vegetation.

With such unfavourable conditions of climate and soil the poverty of the undergrowth is not surprising. In the forest the strength of the winds is broken, and this fact favours the smaller plants but it is outweighed by the freezing of the soil to a depth of from 3 to 5 feet. The bushes, however, are protected by the deep snow-mantle of winter. In spite of this, the frost makes root-life

Fig. 49. Tree Limit in Northern Russia.

impossible, and it is not until the frozen layers have thawed that plants are able to revive. The changes of volume of the ground-water with freezing and thawing are another hostile factor, for the rootlets may become torn or injured. The small shrubs and herbs depending entirely on the surface layers of the soil are thus placed in a precarious position for the greater part of the year. Again, the resin-impregnated needle-leaf mould is generally understood to be detrimental to plants, acting as a

sort of poison; and the continuously dim light due to the persistence of the coniferous leaves (except in the case of the larch) also acts unfavourably on most plants, and excludes bright-flowered species, which need plenty of light for blossoming. Only a few plants can survive all these disadvantages; hence the monotonous nature of the undergrowth and its poverty both in individuals and species. A certain number of evergreen or deciduous, very woody shrublets and creeping perennials are adapted to this mode of life, viz. those which, provided with sufficient reserve material, are able to start growing as soon as conditions improve, and to take advantage of all the very irregular spells of good weather which mark the opening of the season.

Few annuals resist such climates, for the frequent recurrence of frost and high winds in early spring usually kills them in the seedling stage. Tiny plants, whose cycle of life requires but a very few months, or even weeks, are among the features of the north.

The taïga is extremely useful for its soft timber, which it supplies to the whole world. Lumbering is the chief occupation in it at the present day, and has given rise to several important industries. The logs are mostly floated down the rivers to large saw-mills erected on the banks, and often driven by water-power. The wood is used for carpentry, joinery, and match-making. It also yields tar, wood-alcohol, and other chemical products, obtained in numerous distilleries. Mills have been built to reduce the wood into paper-pulp, and to feed these the lumberers have cut their way into the heart of the American taïga. The old-world forests in the Russian Empire have been less injured.

The chief occupation of the forest dwellers, however, has been fishing and hunting for fur and feathers. The

taïga is the home of a large animal population, the pursuit of which has supported a nomad army of hunters and traders. The backwoodsmen, whether Indians or half-breeds, Samoyeds, Buriats, or Yakuts, have remained at a crude and primitive stage of civilization. Trading posts where the skins and furs are bartered are the only settlements of the northern portions.

The southern belt of the taïga is a more favourable field for agriculture. Barley, oats, and rye can be grown where the soil is fairly rich. Under the spur of necessity northern farming has even made bold strides in recent years; and on the southern margin of the taïga the plough is more and more following the axe.

CHAPTER XVIII

TUNDRA—COLD DESERTS OR BARREN GROUNDS

A DWARF, treeless, shrubless vegetation extends over the vast plains and islands beyond the limits of continuous forests or taïgas around the polar cap. Its southern limit corresponds to the northern limit of tree growth, and roughly coincides with the Arctic Circle.

The tundra is a bleak expanse of waste land, with a scattered, stunted vegetation. The landscape consists of monotonous, flat or rolling plains, broken in places

by rugged dykes, rising here into low, rounded, bare, rocky mounds, and bestrewn there with stony or pebbly tracts, varied by gentle slopes, intersected by numerous rivers or streamlets, and dotted over with lakes and swamps.

Continuous night and also continuous light may last for some weeks each year. Frost prevails during eight months of the year, but during the brief summer the temperature rises and falls irregularly according to the situation. On islands, particularly on those on the west of the continents, such as Spitsbergen and Novaya Zemlya, there may be very broken weather, interrupted by blizzards, hailstorms, and persistent fogs. In more continental situations, such as the northern coasts of Asia and America where there are large land masses to the south, the summer appears to be more steadily sunny, broken only by gales of icy winds. Wind is indeed one of the terrible features of the Arctic climate. During the long winter night it may howl for days on end, icy-cold and extremely dry—so dry, in fact, that the breath does not condense as it leaves the nostrils, and tobacco crumbles to dust. Water is precipitated mostly in the form of snow, hail, and fog. Vast regions lie buried under snow for over two-thirds of the year. In others, the winter wind is so dry and strong that it carries away the thin layers of powdered snow as they are deposited, and leaves the ground quite bare. The soil is also unfavourable, for in the dry tundra the frost-bound ground, deprived of the snow-mantle, is exposed to the full fury of the icy gales; and in moister regions the ground may always remain frozen except for a thin superficial crust.

This seemingly uninteresting tundra has many diverse aspects. (1) The most desolate is the *stony tundra*. The

bare ground of stones and pebbles, gravel, or clay, is thinly bestrewn with a few dwarf plants, patches of lichens and mosses, or tussocks of flowering plants, mostly evergreens with tiny, leathery leaves and strong, woody, perennial roots. Here and there a dwarf juniper or birch may be seen.

Fig. 50. Tundra in Northern Russia.

(2) The *moss-heath*, or *moss tundra*, has a less forbidding appearance. It is composed of dense mats, two to four inches thick, of the larger, straight-stemmed mosses. It may be quite continuous, or ragged and full of bare patches. It rests on a thick, damp pad of brown felt and raw, acid turf, known as raw humus, always more or less swampy and peaty. Here and there tussocks and dwarf bushes of crowberry, birch and willow, bilberry, &c., rise above the broken ground.

(3) The *lichen tundra* is a drier type, found in the shelter of the shallow, stony depressions in rolling or hilly parts, where the atmosphere is relatively moist and still. As lichens simply lie on the ground without any roots they depend entirely on the moisture in the air. Exposed situations, open to the dry winter gales, are unfavourable to them. On the other hand they flourish

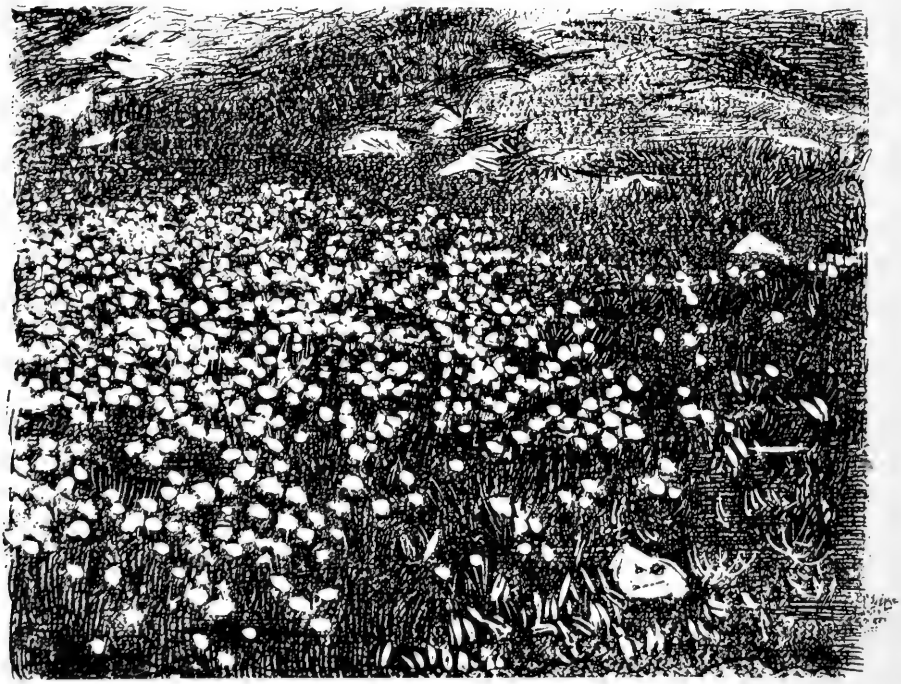

Fig. 51. Cotton-Grass Tundra in Northern Russia.

where they can lie under a thick blanket of snow for six or eight months and in summer are sprayed over with frequent drizzles, rains, fogs, and hail. They are queer-looking, leafless, crooked, miniature soft bushes, one or two inches high, spreading and intertwined so as to form a sort of yellowish-grey mat, often powdered over with blood-red or yellow fruits, on a thin layer of raw mould.

(4) The mossy tundra, under favourable conditions, may become so overgrown with dwarf undershrubs and shrubby perennials as to deserve the name of *dwarf-shrub tundra*, or *dwarf-shrub heath*. In Arctic regions

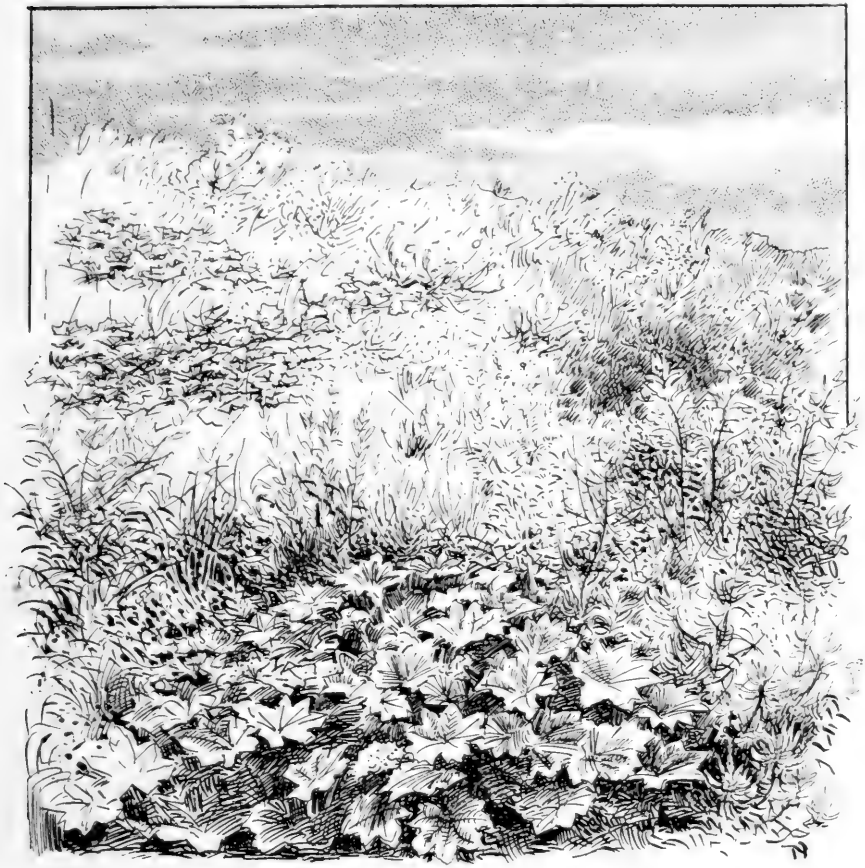

Fig. 52. Bloom-Mat in Northern Russian Tundra.

heather plays but an inconspicuous part. More common are other tiny-leaved evergreens—crowberry, different sorts of bilberry and bearberry, stunted rhododendrons and azaleas, &c. The ground underneath is carpeted with mosses and lichens spread over a more or less thick layer of raw humus.

(5) On badly drained ground are morasses, with pools of stagnant water or overgrown with cotton-grass and sedges, on which *peat-moss tundra* develops. This is a damper variety of the moss-tundra, where raw humus has accumulated to the extent of building peat.

(6) Along the streams are tracts where the remains of dead plants carried away and deposited in the mud make a more fertile, sheltered soil, on which fresh green grasses mixed with flowers grow in profusion *grassy tundra.*

(7) The most luxuriant type of vegetation in the tundra is found on slopes sufficiently steep for good drainage yet retaining enough moisture. When these slopes are sheltered from the dry winds and almost perpendicular to the sun's rays they are quickly warmed in summer, and on them thrive the most delicate and brilliantly coloured flowers of the tundra; these bright spots are called *flowery tundra* or *'bloom-mats'*. They contain only herbs. Among the flowers may be enumerated monkshood, aconite, angelica, geranium, willowherbs, achillea, geum, parnassia, sibbaldia, artemisia, yarrow, polemonium, forget-me-not, saxifrages, &c.

The absence of trees and the extreme stunting of all vegetation are the most noticeable features of the tundras. It is not the cold alone that excludes trees, for trees grow in Siberia where the temperature ranges from $-58°$ to $+122°$ F. The probable causes are the dry winter winds, producing an enormous evaporation at a time when the ground is frozen, so that no water is available.

The greatest cause of the reduction in size of the vegetation is, of course, the shortness of the period of active plant life, which lasts only two months every year; and in some places even this is interrupted. No doubt the sun shines almost all day for some weeks or months

and growth is continuous (except during blizzards). It is possible, however, that a continuous illumination retards the growth of plants in length. About the middle of July all plants burst into active life at the same time, as if by magic. They develop rapidly, and reach their best in a very few days. They live very actively for six weeks or two months, accumulating quantities of food materials which pass into the protected underground parts, root-stocks, and roots. In this respect they resemble the desert vegetation after rain. The close of the season is as abrupt as the beginning. According to the arctic observer, Kjellman, 'an arctic landscape at the approach of winter most resembles a southern country that has been ravaged by a severe night frost before winter was expected. Many plants are put to rest while still in full development. There they stand with frozen but living leaves, with swollen flower-buds in the inflorescences, with half-open and fully expanded flowers, with half-ripe or quite ripe fruits. Whilst the plants were in full activity they were paralysed by the benumbing cold.'

Contrary to expectation, in these bleak countries flowers assume an extraordinary brilliancy, and in many places the bright colours even of the foliage have aroused the enthusiasm of travellers. It is said to be partly due to the long, continuous daylight. The fruits and seeds of certain plants have time to ripen, but in many other cases they are frozen before maturity.

Animals are abundant on the tundra, and many of them provide valuable furs and feathers. Hence, as in the taïga, hunting and fishing are important occupations. Some of the miserable tundra-dwellers of Eurasia, such as the Lapps and Samoyeds and others, depend for their food, clothing, and much else almost wholly on

their herds of reindeer; the only additional supplies afforded by the vegetation around them are a few berries gathered during the short summer. It follows that they are nomadic peoples, living amidst the greatest hardships.

Fig. 53. Mountain Vegetation.

CHAPTER XIX

MOUNTAINS

Diversity of vegetation is most strikingly seen in mountain regions owing to rapid changes in the conditions of climate, soil, exposure, drainage, &c. As

FIG. 54. This shows the upper part of a mountainous region (Upper Engadine). Notice the limit of trees, the pasture above. Immediately below the snow is the zone of 'alpine' vegetation. (Photochrom Co.)

mountains deflect the winds upwards much moisture is condensed. Hence they are wetter than the adjacent lowlands. Their vegetation is usually more luxuriant than that of the neighbouring plains. Even in desert regions, forests and rich pastures may be found among the mountains.

The various vegetations are arranged in bands or belts lying one above the other. Such bands may be appropriately termed girdles or zones, and their margins, limits. In some cases a girdle may encircle a mountain at a fairly uniform level and with a fairly uniform breadth. Much more frequently the girdle is tilted; it may be narrower on one side, or discontinuous, or it may even appear on one side only. Three types of vegetation succeed each other from the base to the summit of a mountain: woodlands, grass-lands, and cold desert-lands. The details, composition, and limits of these vary from equator to poles, from region to region, and even from slope to slope.

The Swiss Alps have three main girdles—the basal or lower girdle, the middle or montane girdle, and the upper or alpine girdle. The lowlands of Switzerland consist of a park-land of beech forests and luxuriant meadows, much altered by agriculture. The basal girdle is similar, but more heavily clad with beech forests, alternating with other broad-leaf, deciduous woodlands. In the montane girdle the forests consist mainly of conifers. At the lower levels they are mixed with deciduous trees, e.g. chestnut and beech, and clumps of such trees as rowan and maple. Higher up are more uniform belts of spruce, which still farther up alternate with patches of larch and pine. These become more and more important until they spread out in a fringe above the spruce. A belt where the pines occur only isolated or in small clumps

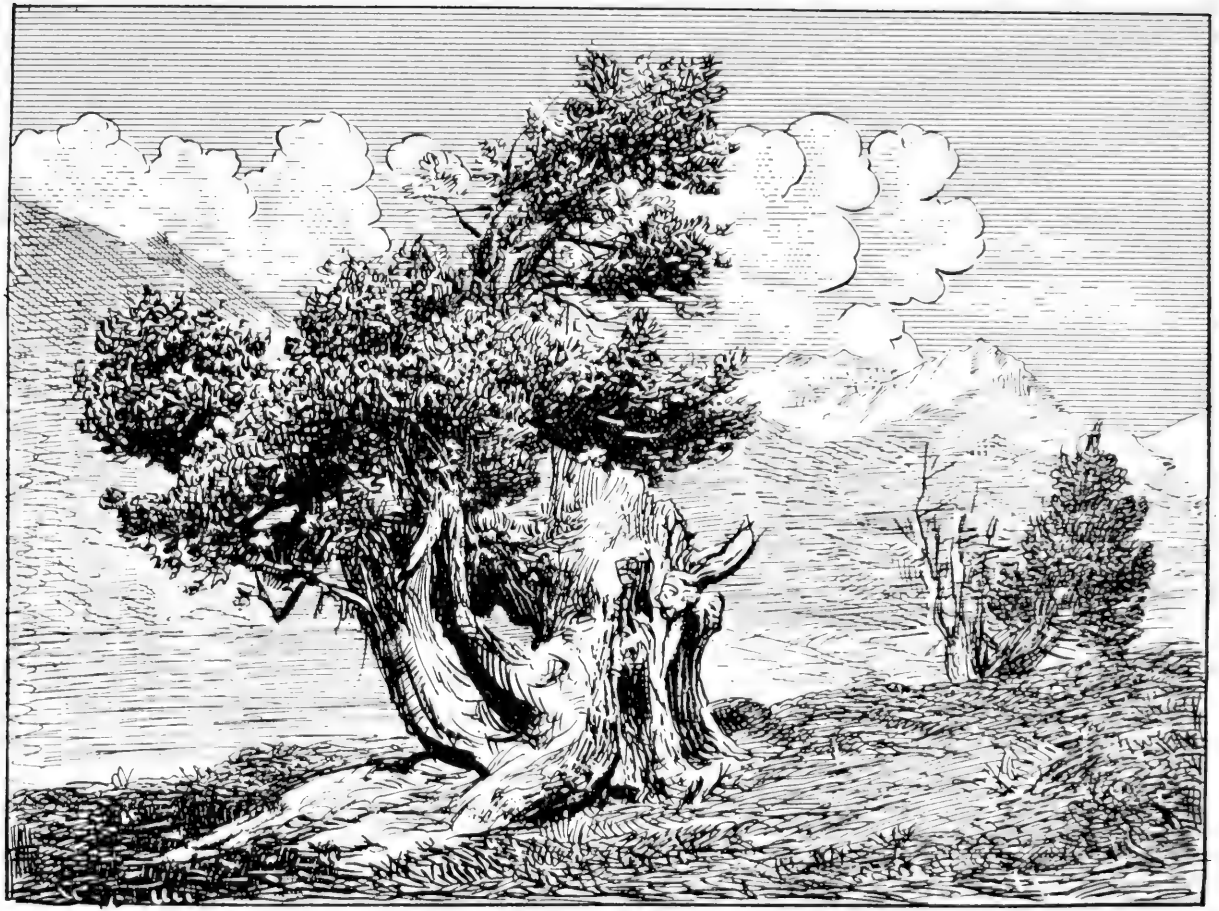

Fig. 55. Tree Limit in Alps. Arve.

succeeds and marks the lower limit of the alpine or upper girdle. The latter consists first of a strip of '*elfin woods*'—made up of dwarf, bushy pines, alternating with shrubberies of short green alders or rhododendrons. The shrubs are surrounded by pastures gaudy with bright flowers, here rich meadows, there carpets of drier grass bestrewn with crawling junipers. This pleasant landscape gives way farther up to rocks and screes, presenting a more and more arid appearance, and studded with low, broad cushions of densely packed plants, extending up to the snowfields.

In the Scottish Highlands the sequence of girdles is slightly different. The beech forest is the lowest and is followed by a belt of oak which extends to 800 feet above sea-level. The pine forests, which also occupy large tracts of light and poor soil in the lowlands, are found above the oak, and are much interrupted by pastures, heather-moors, and peat-bogs. The tree-line in a few cases stands as high as 1,800 feet. The alpine girdle consists of varied landscapes of pastures, morasses, and short brushes, and of screes with their dwarf cushion-plants.

Mountain vegetation has no uniform pattern all over the World. It is very varied from range to range, although preserving a similar vertical order everywhere. Tropical mountains have a great diversity of vegetation, owing partly to great differences in rainfall and winds, partly to the nature of the flora in the adjacent lowlands. On the eastern slopes of the equatorial Andes, where the climate is extremely moist, the heavy rain-forests rise to a great elevation. But on the western slopes of the Peruvian Andes, which are dry and barren, there are only broken strips of dry scrub and thornbush between the coastal desert and the high, arid plateaus.

The sequence of vegetation from equator to pole may be compared with that from the base to the top of a tropical mountain. If a sinuous line be imagined running from south to north through far eastern Asia it will cross the tropical rain-forest, the warm evergreen rain-forest, the cool broad-leaf forest, green only in summer, the coniferous forest, the northern moors and pastures, and the polar ice. Now this is in the main the order of succession which is seen in an ascent of the

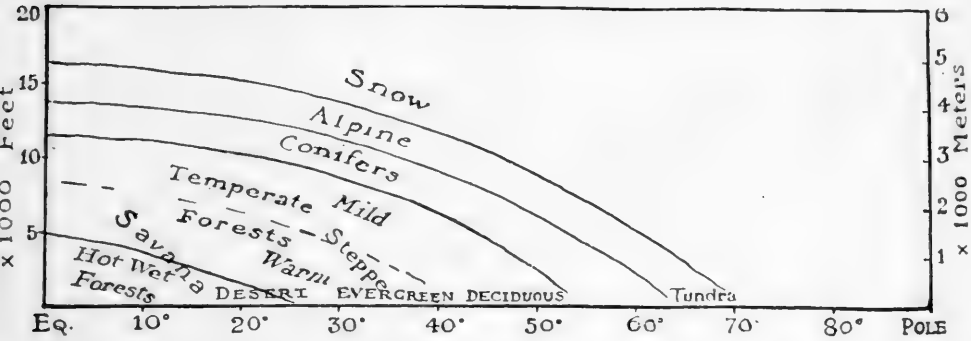

Fig. 56. Vertical Zones or Girdles of Vegetation. This is a generalized diagram. The conditions along the western coasts are shown in capital letters.

eastern Himalayas. Similarly, the zones of vegetation which follow one another on a mountain such as the peak of Orizaba, correspond broadly with the various belts which one would encounter from the West Indies to Labrador. There are, of course, obvious differences and endless varieties, but the comparison is, on the whole, correct.

The altitudes at which corresponding zones of vegetation are found on different mountains depend on many circumstances—such as temperature, rainfall, winds, steepness. Thus, round the World on the parallel of

40° N., the upper coniferous forest is found reaching to altitudes as varied as 5,550 feet in Japan, 7,600 feet on the Tian Shan, 6,600 feet on the Caucasus, 5,600 feet in Macedonia, 6,000 feet in Italy, 6,500 feet in Spain, 5,500 feet on the Appalachians, 11,000 feet on the Rocky Mountains, and 9,000 feet on the Sierra Nevada. From

Fig. 57. Spruce and Aspen Mountain-Forest in Colorado. (Photo: A. W. W. Brown.)

south to north the same girdle decreases rapidly in elevation until it hardly rises above sea-level within the polar circle. This decrease in altitude towards the poles is noticeable for all vegetation zones, though it is strongly influenced by local circumstances.

The causes of the variation in plant life from the base to the summit of a mountain are primarily climatic.

There is a regular decrease of temperature as we ascend. The rainfall increases up to a certain height, and then it diminishes rapidly. The density of the air also decreases regularly, so that the variations in temperature from day to night and from sunlight to shade are very great. This favours strong and frequent winds. At great elevations winds and the rarefaction of the air

Fig. 58. Pine Forests in South Canadian Rockies.

cause an excessive evaporation of water. For these reasons, while the mild or cool but rainy girdles are heavily forested, those lying above the line of greatest rainfall, which receive a limited supply of moisture in the shape of mist, drizzle, and snow, are more favourable to grass-land. The moisture goes on diminishing until it is insufficient for grass, and there follows an arid climate which supports only a carpet of desert plant forms.

The forested mountain girdles have long supplied the world with timber, and the upper grass girdles afford good summer pasture for cattle and sheep. The steepness of the sides confines cultivation to the bottoms and lower slopes of the valleys. The forests were the abode of woodman and hunter, while the grass-lands during summer were the home of a pastoral population. In course of time the mountain-forests, attacked at their lower margins by the ploughman, at their upper margins by the herdsman, and at their heart by the lumberman, have been greatly reduced, and in many cases destroyed, and pastures have replaced them where the climate was not too dry. Mountain-forests act like sponges, retaining part of the rain that falls on the slopes, and delivering it gradually to the adjoining lowlands; their destruction has therefore been attended by results disastrous to the inhabitants of both highland and plains.

CHAPTER XX

ALPS

Above the timber limit is the alpine zone proper. On the whole, its vegetation is analogous to that of the tundra. Its climate possesses, however, well-marked peculiarities.

The vegetative period is very short, ranging from one to three months, according to altitude. Beyond a certain elevation there is practically no period of active growth, the temperature remaining constantly at or below the freezing-point. This elevation varies greatly according to latitude and the general climate, and even from one side to another of the same mountain, since a more rainy or snowy side has the snow-line lower than a drier slope.

The regular alternation of day and night in the alpine girdle of middle and low latitudes, as opposed to the long summer day and winter night of the Arctic regions, constitutes an important difference between the climates of the polar and the alpine regions. Its effect is to halve the time during which alpine plants can take in and accumulate food materials. On the other hand, sunlight is very much stronger on high mountains than in the lowlands, and may, indeed, be too strong. As in the Arctic, the ground is frozen part of the year, and covered with snow for five to eight months or even more (according to position and elevation) where the wind is not strong enough to keep it free.

Three smaller belts are usually recognized in the alpine girdle :

(1) There is a fringe of shrubs above the timber-line. It may be continuous, or scattered in patches surrounded by grass, or again restricted to the slopes of valleys. Peculiar dwarf and gnarled trees, no taller than bushes, strangely crooked and crawling, often covered with lichens, form

Fig. 59. An Alp. (Photo : Miss H. F. M. King.)

what the Germans call 'Krummholz', or Elfin-wood. It is composed of various trees in different countries ; in the Alps it is represented by the dwarf pine and a green alder. Rhododendrons, azaleas, bilberries, heather, ferns, and other under-shrubs diversify the landscape of this fringe.

(2) The grass-belt, which begins in strips on the margin of the woods and breaks through the belt of shrubs, now stretches uninterruptedly above the latter. It may

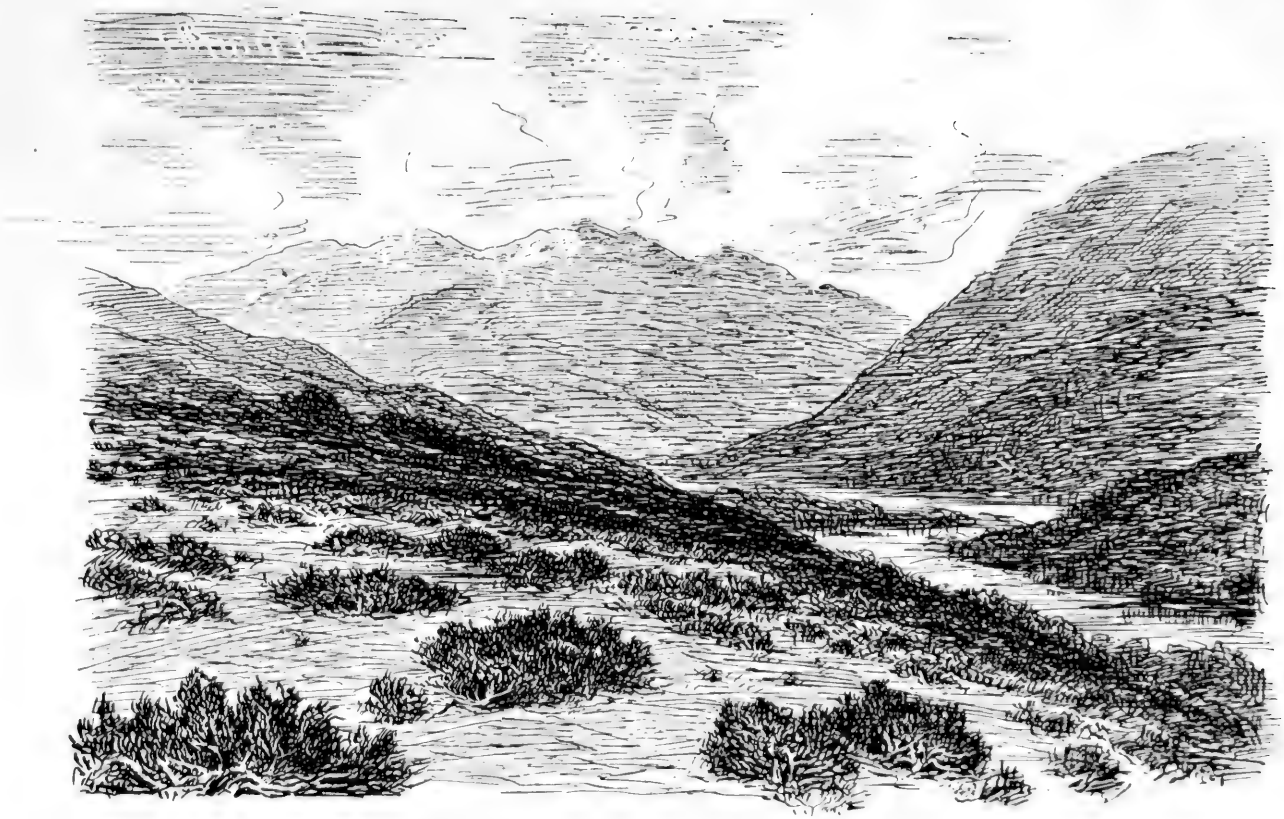

Fig. 60. Crawling Juniper above Tree Limit in the Himalayas.

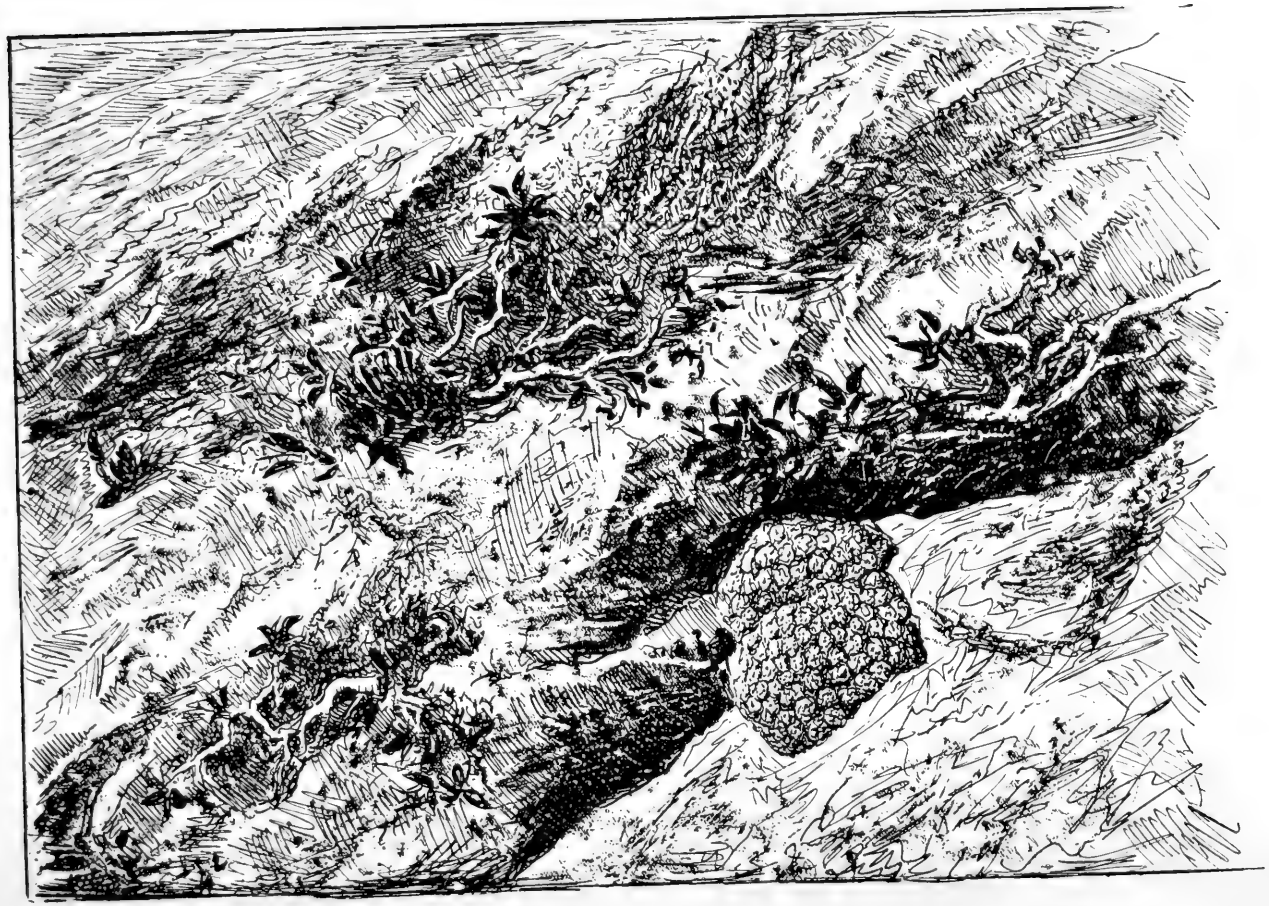

Fig. 61. Alpine Rock and Cushion Plants.

consist of meadows of juicy grass, brightened with showy flowers, or of rougher and drier pastures, studded with the crawling juniper, or again of broken tracts of grass tussocks, showing the bare soil between them.

(3) Above the meadow limit, at which the grass is poorest and most scattered, spreads the cold scree-desert, on stony wastes and rocks, where isolated, cushion-like plants predominate. Tiny, leathery leaves, coverings of white hairs, crowding of leaves and short woody stems packed in tussocks or cushions, strong roots and root-stocks, large and bright flowers, and crawling rosettes of leaves, characterize the plant-life of the last belt. Baskets of dwarf, compact shrubs hang frequently from the ledges and fissures of the rocks.

The alpine meadows provide grazing grounds for the pastoral populations, who migrate thither from the hot lowlands every summer with their flocks and herds, and erect temporary shelters or summer camps. A similar custom prevailed in the Scottish Highlands when their inhabitants were still a pastoral people.

CHAPTER XXI

PUNAS AND PAMIRS

Puna is the name given in South America to high plateaus of considerable area lying in the cold, arid zone, some 12,000 to 16,000 feet above sea-level, on the top of the Andes. These elevated deserts are bounded on each side by the jagged rims of the cordilleras, and extend like immense troughs from Peru to middle Chile. The

high plateaus of Tibet and the Pamirs lying at an altitude of 15,000 feet possess similar features of climate and vegetation.

The punas lie above the line of maximum rainfall, and receive but little precipitation. Most, if not the whole, of this precipitation falls as snow during the winter in daily storms. The air is extremely dry. Owing to the peculiarly clear and rarefied atmosphere, with practically no moisture to regulate the effects of the sun, very great extremes of temperature, both annual and daily, occur. A severe frost at night, followed by a fierce heat at noon, is the normal condition, especially on the sub-equatorial punas. Again, the difference between sun- and shade-temperatures may amount to as much as 54° F. Hence the rocks and soil are being constantly split and broken up by the abrupt changes in volume. Strong, icy winds prevail the whole year round, sweeping over the broad plateaus and carrying away the thin mantle of snow as soon as it falls.

As a result of these conditions salt or alkaline tracts abound, either as temporary lagoons or as drier patches. This feature, intimately connected with a bad drainage and a desert climate, is detrimental to plant life. The soil is generally very poor, stony, pebbly, or sandy; often permeated with salt, seldom fertilized by atmospheric or river deposits, and nearly always parched.

The vegetation that can withstand such conditions consists of a sparse dotting of grass-tufts and other low plants. Grass is the chief constituent, and occurs in bunches, 12 to 18 inches in diameter, mostly circular, 'stiff, hard, brush-like, and almost always covered with sand on the side of the prevailing wind, so that only a segment of the circle vegetates, and even this for the

greater part of the year appears yellowish, grey, or blackish, as if charred.' Rocky tracts support a curious vegetation of cushion-plants of the alpine type. The short stems, topped with rosettes and densely crowded together, offer as little grip as possible to the wind. They build low mounds or cushions, which strong, woody roots anchor deeply among the rocks. Leaves are reduced to short, thick scales, pressed against the stems and protected by a strong, leathery skin. The tubers and deep thick roots which characterize the low-lying deserts are also present here.

Such is the high puna, *puna brava*, the most formidable one. There are, however, lower punas, in which life for both plants and man is just barely possible, and where in some protected parts even thin, low crops of northern cereals can be grown. These have more the character of poor, dry, high steppes.

A somewhat similar vegetation exists in the flat valleys of the Tibetan plateau.

The punas and pamirs can only be regions of transit, and are almost uninhabited. They support in Tibet herds of yaks, wild asses, and sheep, and in South America, llamas and alpacas, which are used as pack-animals.

PART II

CONDITIONS OF PLANT LIFE

CHAPTER XXII

FACTORS OF PLANT LIFE

THE preceding descriptions of different vegetations have shown that there is some relation between plants and their environments. These environments vary in character, and among the changing elements are heat, water, light, wind, soil, and others which we may term the *factors* of plant life. It will be useful to consider each factor in detail and summarize briefly its effect on vegetation. This we can do only for a few of the more important factors. In all cases it is very difficult to separate the action of one factor from that of the others.

A plant is a living organism which is growing constantly, for it is ever changing and ever increasing its volume. We can see but a small part of these changes in the outward appearance of the plant, just as we see in the external appearance of animals only a minute portion of all the changes that are continually taking place in their bodies. In order to grow, a plant requires materials from outside wherewith to build up new substance and replace that which is expended. As in the case of animals, only a limited number of materials serve as plant-food. These enter into its living, active substance in very varying quantities.

Water forms a large part of every plant, and is the first requisite of living vegetation. Other bodies can pass into the plant only when dissolved in water, for plants take their food in a fluid state. Water is thus of the utmost importance, not only as a food itself, but as the medium which conveys other food-materials into the body of the plant. This means that there is a surplus of water which must be got rid of to make room for new water laden with more food, so that a constant stream through the plant is necessary.

Air, or a portion of it, goes to the making of the living matter, and is therefore another plant-food.

The plant-food, when introduced into it, is inert and useless. It has to be transformed by the living substance, or protoplasm, which gradually changes it into living matter like itself. This can only take place under certain conditions, the first of which is the presence of an adequate amount of heat and light.

Though these and other requisites exist everywhere, they do not occur in the same proportions in all places. Plants differ in organization, each possessing characteristics of its own, and requiring more or less of this or the other food or condition than another plant. Every environment has some plants which can live in it. Each part of a plant has its own partialities. An amount of water, light, air, &c., which may favour the growth of the roots may not suit the production of leaves, the formation of the flower, or the ripening of fruit and seed.

Plants are not mechanically built, but are plastic and will alter the number, size, shape, colour, and structure of their parts according to circumstances. The whole science of agriculture and gardening is based on this fact.

Plants require more than food. Many depend on

wind, water, animals, heat, and light for the dispersion of their seeds or the fertilization of their flowers. Others depend on the nature of the ground for the firm anchoring of their roots. Others find enemies in certain animals which may eat or otherwise damage them. Even among plants themselves there is some sort of interdependence. Certain weeds may crowd out the good crops. Plants can kill, injure, or drive out each other. Each plant needs a suitable environment. No plant can thrive and spread in all environments so as to become a feature of the vegetation.

CHAPTER XXIII

HEAT

HEAT is extremely important in plant life. From equator to poles vegetation steadily decreases in size, luxuriance, and variety, and from base to summit of mountains a similar reduction takes place. But so many different agencies are at work, complicating the influence of heat, that it is difficult to determine what is due to heat alone.

Other things being equal, the cooler the climate the more slowly plants will grow and the smaller they will be. From uniformly warm climates, if there is sufficient water, plants of luxuriant growth may generally be expected, while from uniformly cold climates only smaller plants with spare, slow growth may be looked for.

Different plants behave quite differently in their demand for heat. Each part of the same plant has

different requirements in that respect. Every plant will develop best with a certain sequence of temperatures; it breathes best at one temperature, sprouts best at another, leafs best at a third, and flowers best at a fourth. In our climate many plants require less heat for developing their flowers than for leafing. Gardeners know this, and in many cases obtain the growth of flowers or of leaves at will.

The extremes of cold and heat which plants can stand are very important, and these vary greatly for different plants. Temperatures well above the freezing-point may kill some plants from hot countries, whereas temperatures of -95° F. (-70° C.) may leave unharmed other species from cold climates. On the other hand, leafy plants have been known to thrive at temperatures of about 160° F. (70° C.), while others, even from warm countries, were killed or injured at temperatures of 95° to 105° F. (35° to 40° C.), temperatures which may be reached in the sun in our own country, or even farther north, on a very hot summer day.

Sudden transitions of temperature are still more dangerous than extremes. The fatal effect of a strong morning sun on plants frozen during the night is well known to gardeners, who dread the sudden thawing more than the freezing.

Plants that store a large amount of water in their tissues, and those which, owing to a very active life, require a rapid and constant stream of water through them, are particularly susceptible to extremes of heat and cold and abrupt changes of temperature. Cacti, aloes, euphorbias, and other fleshy plants (so-called succulents) may live in tropical deserts, but all except the smallest are absent from the colder, extra-tropical deserts. On the contrary, plants with a spare, slow,

wiry, compact growth stand adverse conditions much better, and are remarkable for their powers of endurance. Such plants are crowded out of places which favour those with a more active and luxuriant growth. Through all these influences of heat, direct and indirect, numerous species of plants are weeded out in any particular place.

There seem to be many protective devices against cold or heat, but little is yet known with any certainty about them. Apparently naked and unprotected plants are found, even at the flowering stage, entirely frozen for months at a time, which, when thawed, continue their growth from the point at which they had been surprised by the cold, to all appearance quite unharmed. Advantage is taken of this trait by florists for providing lily of the valley and other flowers out of their usual season.

CHAPTER XXIV

WATER

Water exists in the air and in the ground. Most of the larger plants derive their water from the ground through the roots, and lose it by transpiration, i. e. they get rid of it as an invisible vapour through tiny mouths (stomata) dotted over the skin of their leaves and stems. An atmosphere containing a large amount of water vapour is favourable to plant life. Where it exists temporarily or permanently there is abundant vegetation, conspicuous for its fresh green aspect. An excess of water in the

air is only of exceptional and temporary occurrence, and is apparently harmless. Atmospheric moisture may be temporarily deficient, as in regions periodically dry or swept by drying winds, or it may be permanently deficient, as in the deserts.

Plants are protected in many ways against excessive loss of water through the leaves and stems. Wind increases transpiration. As the wind increases in strength from the ground upwards, and as the taller a plant is the further away it is from the source of water supply, plants exposed to drought are generally shorter, and therefore stouter. The delicate leaves, through which most of the water is lost, are reduced in number and size. Their skin is thicker, often protected by a down of hairs, or glossy and coated with wax, resin, or varnish. The whole leaf is more compact and consequently heavier, often rolled inwards. Stems or trunks are protected by a thicker, rougher bark or coat of cork. Buds and young shoots become hard, woody, and often thorny. Conversely, plants that need not fear loss of water are taller, more slender, especially trees, and have broad, thin, light leaves, with many empty spaces inside and many little mouths in the thin skins. The bark of their stems is thin and smooth, and breathes freely. Many trees of the tropical rain-forests guard against alternate excess of rain and drought by having their leaves divided into leaflets, which move freely, standing erect and offering only their edges to the Sun (and turning with it), or drooping in time of rain, like our common Robinia.

An unlimited supply of ground-water can in most cases make up for any dryness of the air. An abundant stream of water in a desert suffices for luxuriant vegetation on its banks. Egypt is nothing but a narrow,

winding strip of country consisting of the well-watered banks of the Nile, in the midst of a dreary and barren desert. By conveying water in canals or ditches man transforms the desert into productive gardens. This is called *irrigation*.

On the other hand, an excess of water in the ground may be harmful, by preventing the roots from breathing freely. In hot countries certain swamp-trees, whose roots are permanently deprived of air in the stagnant water, possess special organs which jut out or bend upwards above the water-level for breathing purposes. On low, marshy, tropical sea-shores the mangroves have such breathing roots. Where ground-water is temporarily or permanently scarce, the plants which thrive best have long and strong roots to tap the water reserves at great depths below the surface. Eucalyptus trees are known for the magnificent display they make in apparently waterless regions, owing to the length of their roots. In some deserts plants have been found with roots over forty feet deep.

All kinds of water are not necessarily good for vegetation. Water containing salts may not be able to ooze into the roots, but may even suck water from them. This is the case in the so-called alkali or nitrate countries. In many marshes the water contains acids derived from the rotting marsh plants. In such cases the ground is worse than dry, and the plants look like those found in waterless regions—stunted, with small leaves or none.

Where water is extremely scarce, many plants survive because they store it in their tissues, give off little or none, and renew it occasionally. They may be described as impervious water-bags. In most of them the leaves are reduced to a minimum; they are greatly swollen

water stores. The baobab, or monkey-bread tree, is the best-known instance of such water-storing or fleshy plants. Others are the aloes, agaves, and cacti and their kindred.

The amount of *available* water is the most potent factor in determining the shape of plants and their mode of life. Those which have an unlimited supply of it in the ground and in the atmosphere are tall, with large, thin leaves. When the supply is limited, plants are smaller, with smaller leaves protected in many ways, with long roots pushed down in search of deep-seated ground-water, which may be stored in their swollen bodies. The growth and life of the water-loving plants is continuously active and luxuriant, whereas those in dry conditions live a slow and thrifty life, a kind of dormant existence broken by short spells of intense activity. This is done either by their remaining bare and apparently lifeless for a long period, or by forming bulbs, tubers, and succulents for the dry season. In regions of permanent drought, most plants remain in a state of almost imperceptible life, in the shape of invisible seeds. Under the stimulus of an occasional shower, those seeds which have not perished burst, as if by magic, into ephemeral and humble herbs, only to die out in a few weeks, after producing a quantity of fresh seeds. The capacity of some seeds to remain alive for many years is quite remarkable.

CHAPTER XXV

LIGHT

Light is necessary to plant life, for it is only in the presence of light that the green matter (chlorophyll) of plants can be elaborated. This green matter is essential for changing the raw materials of the food into the living substance of the plant. Where the light is too weak, e. g. under the dense canopy of certain forests, plants tend to grow long, lank, weak, and pale, with few leaves and branches, for their wood cannot mature properly. A moderate light favours the formation of large, thin, dark green leaves rather than of beautiful flowers. A strong light produces short plants, with small, thick, grey leaves, but their flowers are generally large and brightly coloured.

Excessive light destroys the green matter. In countries bathed in sunlight the leaves of most plants, especially trees, move with the Sun, erect or drooping, so as to offer only their edges to its rays. This is particularly noticeable where strong and abrupt alternations of excessive sunlight and rain are of regular occurrence. The mobility of the leaves in tropical forests is quite striking.

Continuous daylight, such as prevails for weeks and months in the far north, induces a growth of plants so intense and rapid that it equals that in more favourable places. Owing to this it is possible to cultivate cereal crops in high latitudes, in spite of the short and cool summers.

CHAPTER XXVI

WIND

The drier the air, the more a plant gives up its water through the whole of its exposed surface, but more particularly through its leaves and the little openings which are found in them as well as on the stems and trunks. If the vapour exhaled by plants is constantly carried away, this transpiration will increase. This is the chief effect of wind. When this removal of water is more rapid than the supply coming through the roots, the exposed parts are liable to dry up and wilt. In this way leaves, buds, and shoots are killed by wind-induced drought. The most unfavourable conditions are found when a dry wind blows over plants that cannot replace the lost water by pumping more from the ground, either because the soil is entirely dry or because it is frozen and liquid water is not available. Such is the case in circumpolar lands, deserts, and the alpine girdles of mountains.

Strong winds may exclude plants with a luxuriant growth, tall trunks, broad and thin leaves, and may limit tree growth, as they do round the poles and on mountains. Even shrubs may be kept out of regions of strong winds, as is the case in the Pacific Islands, where, in spite of water, heat, and other conditions which are eminently favourable to heavy forest growth, mountain ridges and tops exposed to the winds are destitute of trees and even tall shrubs. In fact the limit of shrubs, both arctic and alpine, is in most cases determined by wind.

Nearly all means of protection against drought may be found in very windy tracts—shorter growth, smaller leaves, thicker and more leathery, with their little openings all crowded on the under-surface in deep recesses and grooves. Shrubs and small trees are dwarfed, bent, and kept close to the ground. Shoots and buds that stand out alone are killed, with the result that those which survive are short and crowded together so as to offer the least resistance to the wind. The plants are thus either crouching, expanding into large, low patches, or crawling on the ground. Such tracts are characterized by tussocks and cushion-shaped types. In tropical savanas most trees are umbrella-shaped and in this way present the edge of a wedge to the wind.

Exceptionally violent gales may uproot whole forests. Sea winds may carry some salt water which is dropped on the coasts, where the excess of salt kills most of the vegetation and reduces the rest to such hardy types of fleshy plants or succulents as are common in salt marshes. Winds may also be beneficent. The monsoons and many other winds carry rain to the lands.

CHAPTER XXVII

SOIL

Most of the water and the mineral food of plants is got from the soil. The amount of water in the soil is of the utmost importance, too much being almost as fatal to most plants as too little. The amount of water held in the soil depends largely on the size of the

particles of which it is composed. Rain quickly runs off rocky soils or sinks into crevices. On stony, gravelly, and sandy soils, water sinks rapidly as far as it can and the surface layers are quickly dried by evaporation: such porous dry soils are often barren. Loams and marls, which are made of finer particles, do not allow water to pass so readily through them or to evaporate so easily. They are generally more fertile. Clays, black soils, slimes, and muds offer the greatest resistance to the percolation of water. They are heavy and retentive, and often become cold and clammy, with but little air in them. Their surface often dries, becomes caked, and forms an impervious cover injurious to plant life.

Loams and marls are on the whole most favourable soils for vegetation, but their value varies with climate and other circumstances. The lighter soils do not allow plants with strong roots to get a firm hold, and are not suited to heavy growths like forests. Plants with shallow roots, such as bush or grass, thrive best on them.

In soils where vegetation has grown for some time, the dead and decayed remains of plants (roots, leaves, wood) and of animals (insects, worms, and others) accumulate in the upper layers, making what is called a vegetable soil. When decomposition goes on with a sufficient supply of air, moisture, and warmth, gases, water, and soluble salts are formed which enrich the soil. This is known as mould. If there is not much air, water, or heat, a bad, sour mould, or raw humus, is formed, which is generally harmful to plants. In the most unfavourable circumstances the rotten remains accumulate as a dark coloured, spongy, acid mass, called peat, on which few species can live. Where grass grows

well the countless small rootlets are so interlaced as to make a sort of mat, called turf, which becomes impervious to water and air and harmful to higher plants.

Soils vary greatly in the proportion of mineral food materials which they contain. As in the case of light, heat, and water, each plant has its own particular requirements with regard to food, and what may suit one plant may be poison to another. On poor soils vegetation grows slowly and remains stunted. Some plants cannot grow on certain soils; for instance, chestnut forests cannot exist on soils containing lime.

The growth of grass on our lawns may be helped and the growth of certain weeds prevented by watering with certain solutions. Differences of vegetation are caused by differences of soil as well as by other conditions. One of the most remarkable instances of this is found in salt regions. More than a small amount of salt in the soil excludes most plants; but a limited number of herbs and bushes with small, thick, fleshy leaves and stems thrive on it. As the proportion of salt increases the number of these becomes less and less until we find absolutely bare tracts covered with salt crystals. The saline vegetations are very like each other all over the world, whether along the sea-coasts or far in the interior.

CHAPTER XXVIII

THE HABITAT OR HOME OF PLANTS

When we speak of the place where a plant lives we ought to think of the water, light, heat, wind, soil, &c., which are essential to its growth, and not merely of the space it covers. All these together form the plant's

habitat or home, where it is able to thrive, spread, and produce descendants to replace itself when it dies. When all these conditions are favourable the plant and its environment are adjusted. The adjustment is seldom perfect. Climate is often variable, as in our own country. Plants may be induced to bud, sprout, and flower by a spell of good weather and then be injured or killed by a late frost. In many countries one year may differ considerably from another, the one being dry and hot, the next cold and wet, affecting some plants favourably and others unfavourably, and giving a different appearance to the vegetation.

Plants of quite different characters may be found in the same region. On the Russian steppes the mild, rainy spring brings forth a beautiful display of tender, bright-blossomed meadow herbs and bulbs; but in the hot, scorching autumn there is only a sea of dry-looking, grey, woolly vegetation, giving the steppe the appearance of a semi-desert.

A plant has to reckon with its neighbours both vegetable and animal. Some of these may not affect it at all, but others may either help or injure its growth. On our own hills bracken kills grass, and heather crowds out bracken, sweet-gale drives heather away, and in its turn is conquered by peat-moss, which has to give way before cotton-grass, and so on. On the other hand, the tender wood-anemone prefers the shelter of the beech, and the lily of the valley needs the deep forest mould of the same tree. Many orchids and other plants live on the bark and in the shade of trees: creepers require their support, and may eventually kill them. Many plants feed on the living or dead substance of others.

The same is true of animal neighbours. Worms and

insects may improve the soil and make it more suitable for the primrose, wood-hyacinth, and other bulbs. Insects and birds fertilize flowers and help plants to spread their seed. Slugs, caterpillars, locusts, and others ravage and lay bare whole tracts of land. Certain insects spoil the flowers of certain kinds of plants so that they die away gradually. Leaf-cutting ants may damage a whole banana plantation. Many birds live on insects and worms and help to rid our gardens of these pests. By feeding on fruit, such as strawberries and gooseberries, they help to spread their seeds.

We must then include animals and other plants among things which influence the life and distribution of plants.

CHAPTER XXIX

MIGRATIONS OF PLANTS

We are accustomed to think of plants as fixed and immovable. Yet we know that they spread. If not held in check, raspberry bushes overrun our gardens, and the grass of the lawn encroaches on the paths. The cacao planter of tropical countries has constantly to fight back the forest.

Plants spread not only by the distribution of their seeds, but also by means of their roots and underground and crawling shoots. They spread by natural cuttings and by their buds being carried away, and some even move bodily, swept along by the wind. In these movements they are helped by the rain, river, and sea, by ice and wind, by worms, insects, birds, and mammals, and most of all by man. We speak of the migrations of

plants. We say that the beech and spruce have travelled westward. Knowing that Scotland was once buried under ice, we say that it has been invaded by the plants, coming from neighbouring countries. In some cases we can follow the routes of these migrations or invasions.

When we remember these migrations and the power of plants to change gradually and adjust themselves to new surroundings we can understand how, in course of time, plants have arranged themselves in well-defined groups. Plants requiring the same climate and soil naturally grow side by side. In a meadow several sorts of grasses and herbs grow together. In North European forests the Scots pine and the larch are rivals. In tropical forests many species, to all appearance equally suitable, compete for the ground. At the same time, other plants with different needs may grow between these. Hazel-nut, holly, rose-bushes, brambles, and many others thrive under the cover of an oak forest and form an undergrowth which spreads over the ground between the trees. Beneath this undergrowth willow-herbs, bulbs, lesser celandine, and many others take advantage of the shelter and the mould; while climbers like clematis, ivy, honeysuckle, and bryony find moisture, soil, and support; and ferns, lichens, mosses, and algae colonize the bark of the trees. In this way each plant uses its neighbours for its own purposes, and is so used by them that all render each other mutual services.

Different species of plants with different needs may live side by side without affecting each other, because they do not all produce their leaves and flowers at the same time. Among our wild plants bulbs flower before they are shaded by the leaves of the shrubs, and these shrubs blossom before the dark, leafy canopy of the larger trees diminishes the light. These plant groups

or plant associations must be regarded as communities composed of species with similar requirements and of plants which have what may be called complementary needs to theirs. Similar associations are found in widely separated regions where the general conditions of climate and soil are similar.

The individual plants may vary in different regions without affecting the similarity of the association. A meadow in North America, in Amuria, or in Europe, may be composed of entirely different species, yet it has practically the same appearance, the same mode of life, the same organization, and is found in similar situations. The same associations of plants may be found side by side over wide tracts, where the general conditions are the same. Combinations of forests, meadows, and marshes are well known in our country. On the sea-coast dunes, links, salt-marshes, brakes, heather, clumps of gorse and broom, alternate one with the other. They form *groups of plant associations* or plant landscapes. The North American prairies, the South African veld, the Russian and Asiatic steppes, all make similar landscapes. The complex vegetation of the Mediterranean is similar to that of California, the south-west of Cape Colony, and the south-west of West Australia. These regions can all borrow useful and ornamental plants from each other, as vines, peach and orange trees, mimosas, and acacias.

PART III

SURVEY OF THE CONTINENTS

CHAPTER XXX

NORTH AMERICA

The Barren Grounds. The tundra, which alone can exist in arctic and sub-arctic climates, covers a narrow strip along the Bering Sea coast and the northern lowlands. The Barren Grounds, as the tundra is called in Canada, extend from the mouth of the Mackenzie to that of the Nelson River and over the northern part of Labrador. The wealth of flowers which converts the best parts of the Alaskan tundra into gardens gives way further east to extensive tracts of lichen-tundras, above the level of which the dwarf, crawling shrubs hardly rise. These boundless wastes are inhabited by a scattered population of backwoodsmen—Indian and white hunters and traders, who hunt the caribou and moose, the fox, and other fur-bearing mammals, also the birds which have their home there. Temporary settlements, often mere wooden forts and trading posts, are scattered along the rivers, which afford natural routes for traffic, while their wooded banks provide the necessary timber.

The Scattered Forest. Further south, from the Alaskan and British Columbian plateaus to the eastern point of Labrador, the tundra becomes more luxuriant and dotted over with trees and clumps of trees, mostly birches and conifers; this may be termed the sparse or poor forest, which supports the woodman to some extent beside the hunter.

The Cold Forests. A less forbidding climate is necessary for the dense, continuous forests, chiefly of resinous trees. These cover a large tract of North

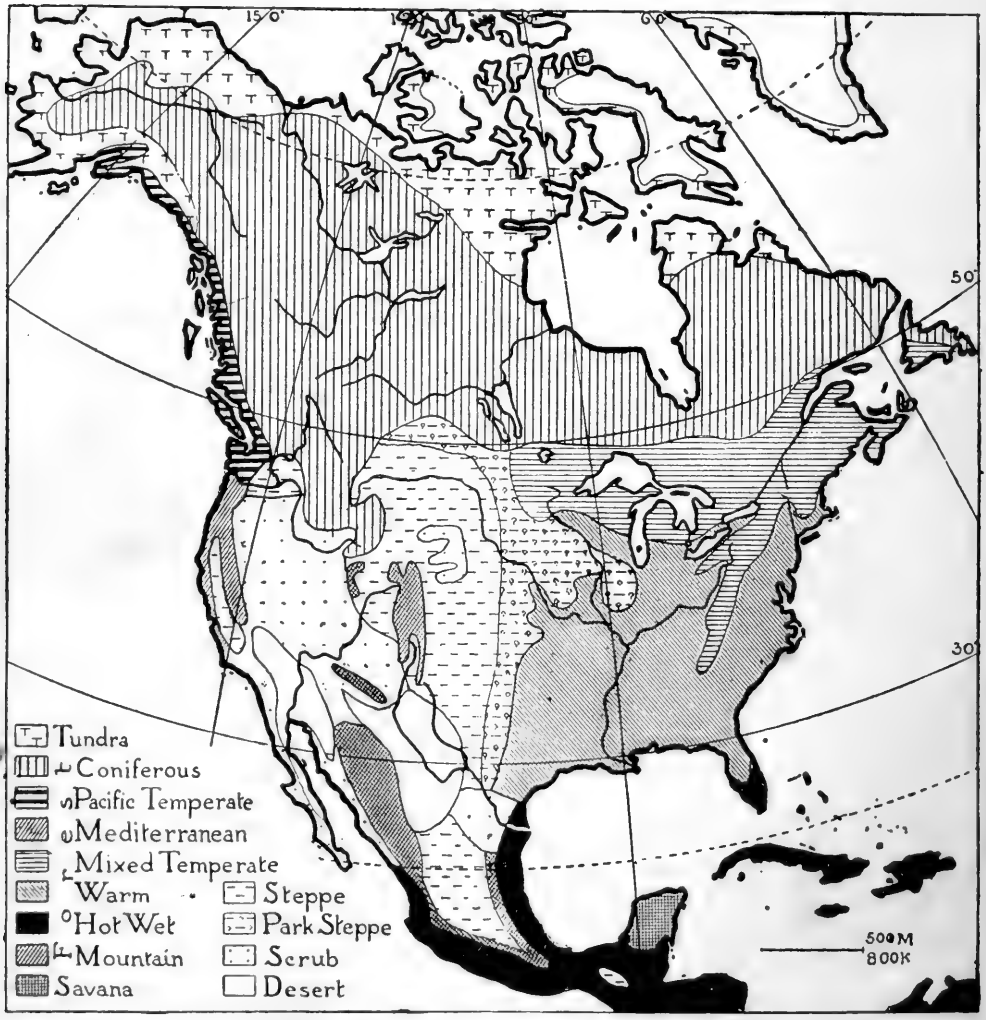

Fig. 62. Vegetation of North America.

America from ocean to ocean almost uninterruptedly, and stretch southwards in long tongues over the elevated eastern and western regions.

The Northern Forest extends from the Rocky Moun-

tains to Newfoundland. It is narrow in the west, where the drier climate of the prairie pushes it to the north, but it gradually broadens to the east in the region of the Great Lakes, where the rainfall is more abundant. It consists of a variety of pines, firs, spruces, larches, hemlock-spruce, cedars, and other conifers, mixed with birches and aspens. The felling of large quantities of timber for paper-making together with forest fires effect vast clearings every year.

Nearer the Great Lakes, where the climate is milder, the Canadian forest becomes more luxuriant. Numerous species of broad-leaved trees, of well-known European types, such as oak, maple, ash, and chestnut, but in much greater variety, form both pure and mixed woods. The landscape becomes increasingly varied. Fruit and dairy farming become important.

The Eastern Forests. Along the Appalachians this mixed vegetation is found as far south as North Carolina, with increasing variety and profusion. Many kinds of hard-woods, tulip trees, magnolias, elms, walnuts, chestnuts, beeches, oaks, birches, and maples, appear mixed with a few stately conifers, while rhododendrons, kalmias, and diverse evergreens beautify the undergrowth. The upper girdle of the mountains is one of conifers.

The Appalachian region has a more generous climate than the Lake region, though more extreme than that of western Europe. It was very heavily forested with deciduous trees, of greater luxuriance and variety and so forming a richer vegetation than our own forests. Their equivalent is found on the rainy south-eastern shores of the Black Sea. According to situation broad-leaved trees are mixed with or alternate with conifers.

The Allegheny Plateau sloping to the Mississippi is (or was) clad with a similar broad-leaved forest, inter-

rupted by glades of grass and a broken belt of cypress—the 'Cedar Glades'. Towards the west, as the rainfall diminishes the forest becomes lighter, drier, lower, and more open with many grassy areas. It gradually passes into a park landscape of the temperate type which fringes the central prairie from north to south.

The Plains. In the south-east the Appalachian region is bordered by a drier, sandy belt where pines grow. The poorer parts are called the Pine-Barrens.

Beyond this is a narrow strip of sub-tropical evergreen, broad-leaved forests, extending over the coastal flats. This frequently passes into wooded coastal swamps where cypresses, palms, and other sub-tropical trees play an important part. This coastal belt gradually broadens on the shores of the Gulf of Mexico, round the Mississippi delta, and in Texas.

To the west of the park landscapes of the Mississippi valley is a belt of brush-prairie or bush-steppe, where open woods appear only as islands. Beyond is the great treeless prairie or steppe, which extends far into Canada and gradually rises to the foot of the Rocky Mountains. In places the prairie is broken by poorer sand-hills, and in Dakota by the barren, broken region known as the 'Bad Lands'. In the south-west the prairie becomes drier and gradually disappears. There is an arid region with thorns, stiff grass, and cacti in western Texas and New Mexico, beyond which lies the semi-desert of North Mexico.

The Western Mountains. In the west, the three parallel mountain ranges running from Alaska to Mexico, in spite of varied climates from north to south and from west to east, are essentially the domain of resinous forests, whereas the plateaus and troughs separating them have a more arid character. From west to east,

the rainfall decreases rapidly and the climate becomes more extreme; consequently the coniferous forests are lower, drier, and more scattered, the poorest ones being found in the Rocky Mountains.

The Coast Range is open to the moist winds of the Pacific and enjoys an equable, temperate climate. The heaviest and densest coniferous forests in the World are found in this area. The resinous forests are of unequalled luxuriance in the centre of the range, near Vancouver. Farther north, as the cold increases, they get gradually poorer; while farther south, as the rainfall diminishes, the vegetation passes gradually to the almost desert forms of Lower California. The much drier Cascade Ranges show the same gradual impoverishment south and north of the state of Washington. The eastern slopes have clearer forests than the Pacific slopes. The Sierra Nevada is remarkable for its giant trees (Sequoias or Big Trees).

Still farther inland the third and driest type of coniferous forests is found in the Rocky Mountains. Again there is a centre of greatest luxuriance in Montana, from which the richness diminishes through drought in the south and through cold and wind in the north. In these three chains the forests are similarly arranged in altitude. The lower slopes are too dry, and the upper ones too cold, windy, and dry for timber, but between them there is an intermediate zone of greater rainfall which supports dense forests. The wealth and variety decrease upwards and downwards from this central level.

From Vancouver northwards the trough between the Coastal Chain and the Cascade Ranges is under the sea. Farther south the trough is known as the **Californian Valley.** It possesses a dry, sunny climate, but snow-fed streams from the southern Cascades and the Sierra

Nevada provide sufficient water for irrigation. Originally the valley was a park landscape with grass-land, scrub, and clumps of hard and broad-leaved woods, similar to the Mediterranean trees and shrubs. By a judicious use of the water it is now almost entirely utilized for agriculture, cattle-breeding, and fruit-farming.

The Cascades and Sierra Nevada are separated from the Rocky Mountains by a series of **high plateaus**, known as the Yukon Plateau, the British Columbian Plateau, the Snake Basin, and the Great Basin, most of which are arid or semi-arid tracts. The British Columbian Plateau is covered by the scattered Northern Forest, like the Yukon Plateau. The Snake Basin may be described as a treeless plain, mostly of dry grass-land and sage-brush. In places the climatic aridity is accentuated by the porous nature of the lava which covers vast expanses. The Great Basin, with its hundreds of small rocky ranges, is a vast sage-brush tract cut off by the Cascades and the Sierra Nevada from the moist Pacific winds. The short, parallel ridges have rocky slopes, dotted with low stunted trees such as junipers, rock pines, evergreen oaks, and scrub, which can hardly be said to constitute a forest.

Between the Wahsatch and the Rockies lies the Colorado Plateau, a monotonous succession of broken, slanting tablelands, deeply trenched by steep canyons and crossed by a number of ranges. Though the climate is on the whole semi-arid and extreme, the landscape has a certain variety. There are meagre pastures of short grass on the tops or mesas, brushes of sage-like bushes or salt-marsh succulents in the valleys, especially in the Rio Grande valley; clear, scattered, and interrupted forests of pines on the slopes of some canyons and ridges, with patches of them here and there on the

plateaus, and small, isolated tracts of wooded alps. The Black Table, or Mogollon Mesa, has a last belt of coniferous forest on the south-west before the plateau sinks abruptly by a great escarpment down to the level of the Mohave-Gila desert. This has an extremely arid vegetation, with sparse dry, bald thornbushes, and a wealth of prickly succulents—cerei, cacti, prickly pears, yuccas, agaves, and others.

Mexico. The Mexican Plateau slopes from the Anahuac Plateau, over 7,000 feet in the south, down to the Rio Grande in the north. It assumes an increasingly desert-like appearance from south to north. The northern and lower portion is little more than a desert with extensive plains covered with a monotonous carpet of low, woody, evergreen shrubs, conspicuous among which is the 'guayule' rubber bush, and inland basins with salt bushes. The southern and more elevated portion is of a less forbidding type. It is more of the nature of a high steppe, much transformed by cultivation. Vast grassy expanses with agaves, marshy plains, thorny scrubs on rocky wastes, and cornfields, betoken a more favourable climate. The jagged rims of the plateau and the steep slopes which sink down to the hot plains are covered on their upper slopes with stately forests of conifers, but lower down they display a more and more tropical character. The western slopes and the plains (except for the malarial coast swamps and the valleys) are largely covered with scrub and light woodland, but the moist hot eastern slopes display the luxuriance of tropical forests. On the rich coastal plain of the Gulf, savanas and sub-tropical woods alternate in the north; but the south, except for the drier savana of Yucatan, is heavily timbered, though much of it has been cleared for cultivation.

Central America. The same characteristics are common throughout Central America. The wetter eastern lowlands, open to the trade winds, are the home of dense equatorial selvas, whereas the drier western lowlands show more of the lighter monsoonal woodlands and savanas. Above 3,000 feet the hill-sides carry a belt of moist temperate evergreen forest, with bamboos and tree-ferns. The higher slopes and summits are covered with shrubs, passing to drier alpine steppes.

CHAPTER XXXI

SOUTH AMERICA

The Selvas. One of the most notable features of South America is the Amazonian selva. A low plain, extending over 2,000 miles inland, subject all the year round to heavy and continuous equatorial rains, in a damp, cloudy, sweltering atmosphere, flooded periodically over vast areas by abundant streams and chiefly by the greatest of rivers, the Amazon, is the home of the densest and most extensive of equatorial rain-forests. What may be described as fresh-water mangrove—the Igapú—forms a belt, with giant weeds closing over an uninterrupted, sombre vault, follows the course of the main river and its countless tributaries, and covers the flood-plain for miles on either side. Beyond the zone of these flood-forests extends the more luxuriant and less forbidding rain-forest, known for its rubber, Brazil-nuts, and other products. The low ridges between the principal tributaries are clad with lighter woods, interrupted by glades.

Savanas, Campos, and Llanos. These extend north and

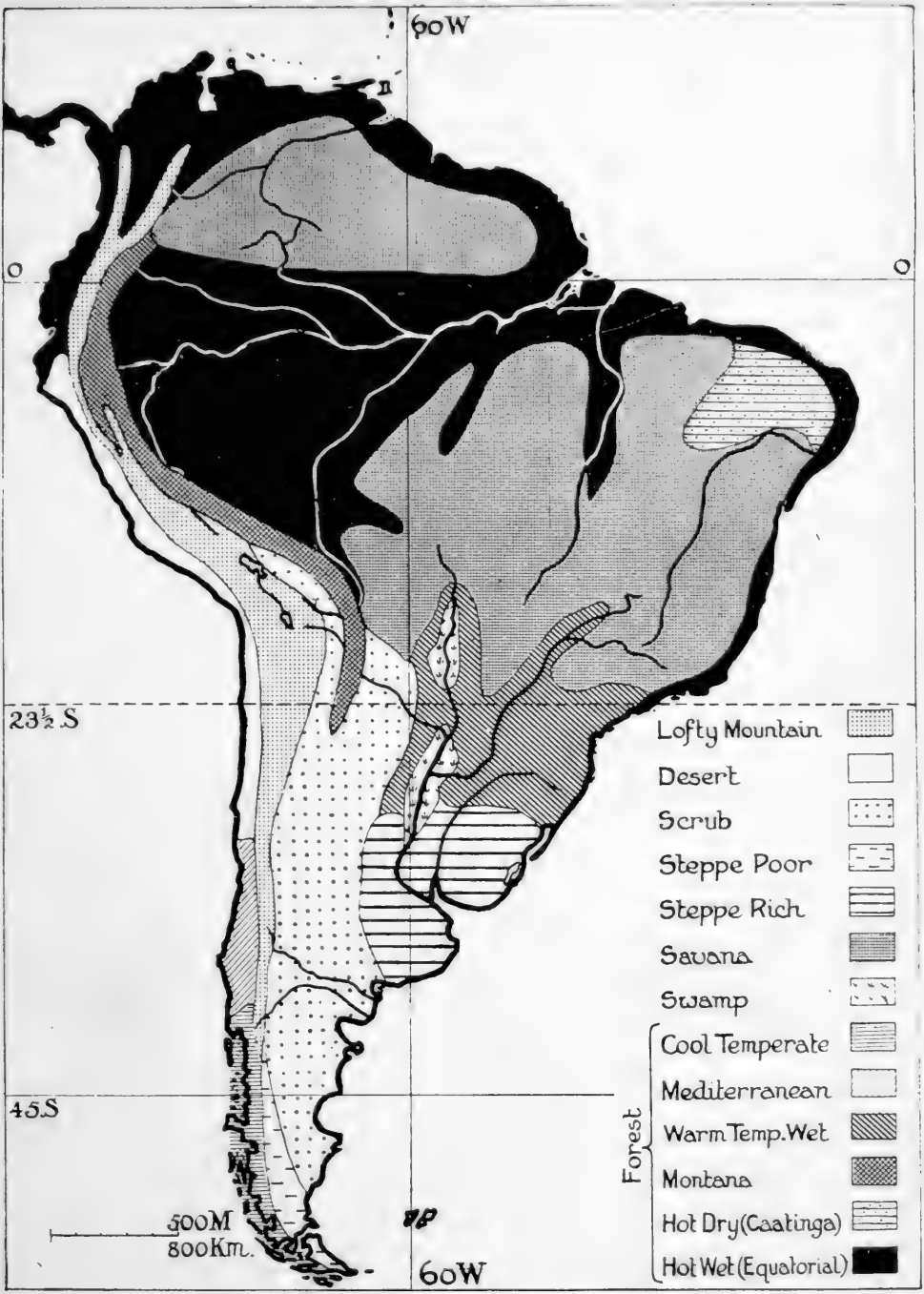

FIG. 63. Vegetation of South America.

south of the selva on higher ground, with a long dry season. The country has a gently rolling appearance, and forms a park landscape of the tropical type, with tall grass on the ridges and open, clear, dry woods standing like islands in the valleys. These lands are rich in pastoral and agricultural possibilities. They are known as campos in Brazil.

The Guiana tableland, rising in terraces to Roraima, has savanas of an analogous type, also called campos, with an increasing proportion of light woods in the higher terraces. They descend in the west to the grassy lowland plains, or llanos, of the Orinoco. Here occasional groves or even isolated palms and river-woods are also found. The Orinoco itself favours the growth of heavy fringing forests on its banks.

Higher Eastern Tablelands. In the higher and more broken eastern Brazilian Highlands the scenery is more varied. Dry woods and scrubs are conspicuous. Light open woods (*campos serrados*) occupy the depressions of the savana. The tall and forbidding thorny scrubs called *caatingas* are found in abundance, especially in the north. The rocky slopes of ridges above these are covered with the lower, poorer, and more open scrub of the *carrascos*, full of cacti and cactus-like succulents. Still drier and poorer tracts, called *sertões*, display scattered shrubs, short, stunted, and thorny, and tufts of stiff grass and perennial herbs. On the west these forms of dry, woody vegetation give place to the savana. Towards the tropic of Capricorn the campo gradually loses its tropical luxuriance and becomes park-savana, where the ridges are grassy and the valleys are covered with sub-tropical evergreen woods.

In **Southern Brazil,** from the sources of the Rio Grande to the Serra Geral, on the broken tableland 1,500 to 3,000 feet high, grass-land alternates with open forests

of araucaria, in which the yerba maté, or Paraguayan tea, is frequently found as underwood.

The Plate Basin. A quite distinct region is formed by the Parana-Paraguay-Pilcomayo basin. The upper valleys of the Parana and Paraguay, trenched in the Brazilian plateau, as well as the broad basin of the Alto Parana, are covered with a tall and dense forest of the moist sub-tropical type. The wide flood-plains lower down, which the mighty rivers cover every year with muddy deposits, are practically one vast, shallow swamp, crossed by natural dykes and strips of grassy higher ground. The parts left dry by the retreating waters are quickly overgrown with low herbs and grass, which form excellent pasture. A broad strip of the strange, light, small-leaved quebracho-forests, with a heavy underwood of evergreen shrubs, fringes the swamp region on the west of the Paraguay River, in the Chaco, whilst, east of the same river, stretch vast and marshy pastures in a framework of wooded rises.

The Pampa. On the south-west of the great Parana swamps lies the boundless pampa, 'the space', a rolling sea of treeless grass, the home of innumerable herds of cattle, deer, ostriches, and horses. As it approaches the Andes it gradually changes to a semi-desert with scattered thorny scrub which extends to the foot of the mountains, and has received the names of espinal and chañaral. The chañar is a dry, thorny, acacia-like shrub.

Patagonia. The espinal is also found south of the Rio Negro in the vast Patagonian semi-desert—a desolate tract of shingle and sand dotted with solitary tufts of stiff grass and low, stunted, gnarled bushes, under a clear, cool sky. Where the tapering tail of the continent extends farther into the belt of westerly gales, and the range of the Andes becomes lower, a little more rain

becomes available. The southern point of Patagonia and the north-eastern part of Fuegia has a broken, treeless steppe of grass tussocks suitable for sheep pastures.

The Andes. Through 4,500 miles, with altitudes rising to 23,000 feet, the stupendous chain of the Andes may be said to summarize the vegetations of the whole World.

The eastern slopes, from Venezuela as far south as the Chaco, receive enormous quantities of rain, and are drained by many mighty rivers. The luxuriance of their rain-forests is unsurpassed. They are hot in the lower parts, temperate higher up, and pass into sub-alpine shrubland and alpine pastures.

From the Chaco to Patagonia the eastern slopes become semi-desert, rocky wastes with solitary clumps of low trees in their gorges, and sprinkled with dry sage- and acacia-like bushes and thorny leafless cacti. Towards the river Chubut the eastern slopes begin to share in the forests of southern Chile, with austral beeches. These descend to the plain, where they stretch along the foot of the range down to Fuegia.

The western slopes are more varied in their vegetation. In Columbia and Ecuador they are covered with lighter tropical forests. Farther south the narrow coastal strip and the western slopes, though exposed to fog and dew, are rainless and desert. The aridity is most marked in the broad strip called the Atacama desert.

South of 30° S. the conditions improve considerably. The vegetation is of the hard-leaved mediterranean type. The Chilean valley is used for mediterranean agriculture. From 40° S. to the extreme point of Fuegia, the western Andes and islands, exposed to westerly storms, are covered with valuable conifers and austral beech rain-forests of the cool, temperate type.

The Columbian Andes form lofty parallel ridges, with

deep and narrow valleys between. Dense hot forests clothe most of the wet bottoms, followed by successive zones of temperate and cool forests. The bleak alpine zone, called Paramos, is covered with a dry, dwarfed grass and low bush.

The high plateaus, hemmed in between the higher cordilleras, like those of Bogotá and Quito, are temperate in climate and vegetation. They have become centres of population and development.

The Peruvian, Bolivian, and North-Chilean Andes contain broad and extensive plateaus lying at great altitudes, and suffering from a dry and extreme climate. These arid *Punas* are thinly covered by a treeless grass-land. Some of the lower and moister portions grow meagre crops of northern cereals, but the higher and bleaker *Punas Bravas* are hardly more than deserts. The Punas, with their alkaline tracts, or salinas, descend by terraces and cordilleras to the coastal Atacama desert.

CHAPTER XXXII

AFRICA

The Dark Continent has no vegetation familiar to us. It is a hot land with extremes of drought and of moisture. Only the higher slopes of the plateaus and mountain ranges enjoy a cool, temperate climate.

Barbary. The north-west corner of Africa, separated by the Atlas ranges from the rest of the continent, is relatively well watered. In its valleys and on its long slopes and plains are fertile lands of olive-yards and

orange-groves, with hilly belts of evergreen oak and cedar forests. This hardly seems a part of Africa. It belongs to the South European or Mediterranean region, with its hard-leaved, evergreen vegetation.

Sahara. The great tropical desert of the Sahara, with its deadly seas of sand dunes, its vast bare floor of clay and stone, its scattered rocky blocks of hills standing like gigantic ruins, its network of waterless river-beds, its chains of oases and wells, is the most remarkable feature of this continent. It is a land of thirst, where the eye occasionally meets a tuft of grass, a half-buried tussock of apparently dead sticks, or a low thorny shrub. In shallow troughs and round springs the palm groves called oases break the monotony of the desert. Man with his train of camels wanders along from well to well and from oasis to oasis.

Egypt. The most remarkable of these oases is the long trough winding through the desert, only a very few miles broad, watered by the Nile and known as Egypt. But for the Nile, Egypt would be the same desert that extends on both sides. Thanks to the water it is able to grow nearly all crops, and its fertility is proverbial. In the north the Sahara passes gradually into very poor steppes of esparto grass and sage-brush. Arabia, in point of vegetation, continues the Sahara eastwards. The southern hilly margin of this plateau, however (the ancient land of the myrrh and frankincense), constitutes a fertile belt between the desert shoreland and the arid interior. It conceals in its secluded valleys an unexpected wealth of woodlands, gardens, and orchards of a sub-tropical character. The heart of the desert is occupied by a large group of oases.

Sudan. The Sahara passes through a belt of semi-desert, a thorny scrubland, into the vast grassy parkland

known as savana. The Sudanese savana extends from ocean to ocean across the whole breadth of Africa, on a higher tableland than the Sahara. Its grass supports

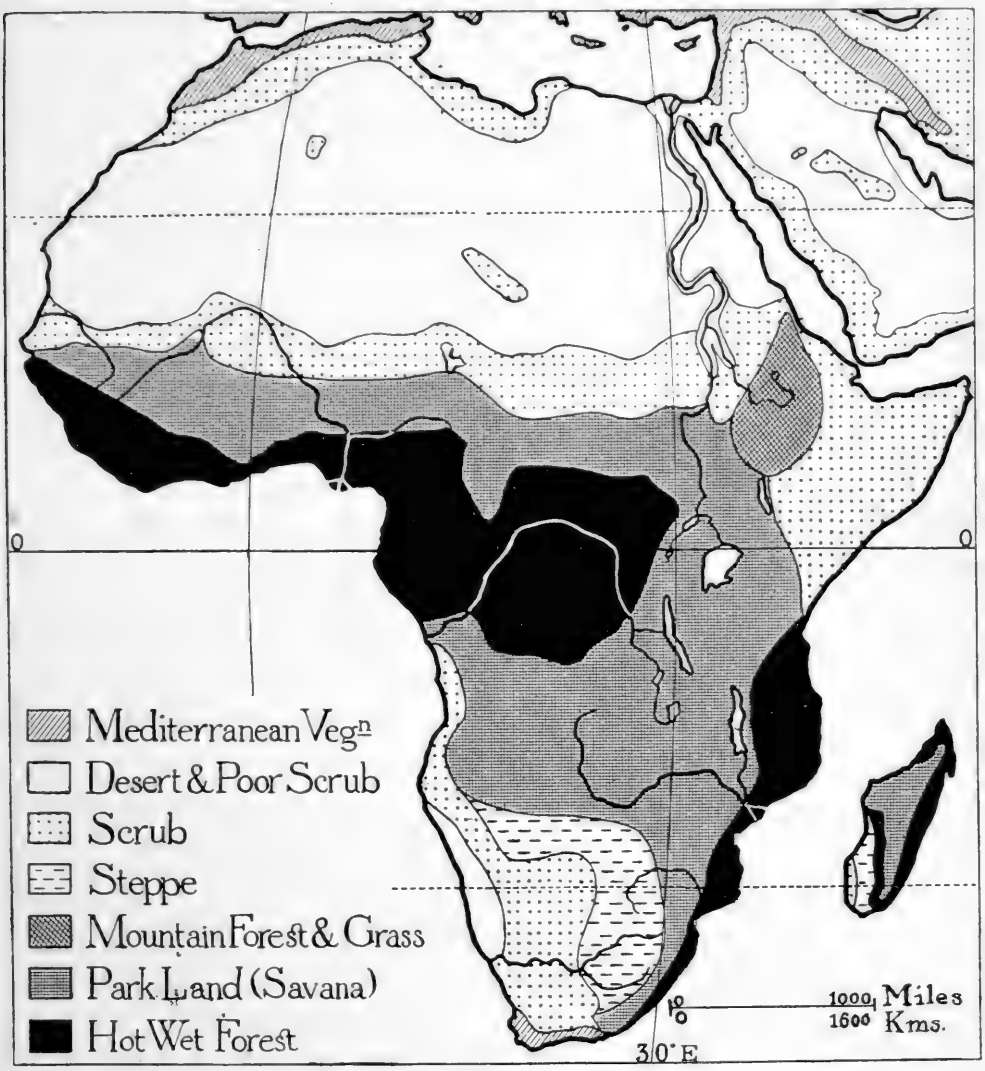

FIG. 64. Vegetation of Africa.

innumerable herds of cattle, both wild and domesticated. Vast tracts suitable for cultivation, often naturally indicated by groves of palms and other trees, offer opportunities for prosperous agriculture. It has con-

sequently developed at different times higher types of civilization, and its possession has been disputed by many races and nations, both pastoral and agricultural, nomad and settled, while it has been plundered periodically by the less fortunate dwellers in the desert. The savana stands as a favoured belt between the arid Sahara and the formidable equatorial forests to the south.

The Equatorial Forest covers most of the slopes and plains descending to the Atlantic along the shores of the Gulf of Guinea and the greater part of the Congo basin, which lies within the belt of heavy rains. So overpowering is the luxuriance of nature under the hot, wet equatorial climate that man is practically crushed out. Only temporary human settlements are found, and these of the humblest type, in constant struggle with the forest which relentlessly closes in upon all attempts at clearing. 'The Congo basin is a circular, plain-like tableland, 1,500 feet above the sea, surrounded on all sides by the edges of higher plateaus.' Its heavy forest, interrupted by belts of lighter woods and vast glades of savana, extends almost to the western rift.

Beyond the equatorial rain-forest of the Congo basin the great **African savana** resumes its hold on the higher South African plateau, which rises as it approaches the scarped edge of the Drakensberg. The landscape is a monotonous succession of tablelands at different levels, here deeply trenched by rivers flowing to the ocean, there hollowed into large shallow depressions, without outlet, made marshy by sluggish streams which die out in salt-pans. Gradually, with increasing latitude and altitude, the Zambezian savana loses its tropical character and assumes the type of sub-tropical park landscape known as Bushveld. Farther south this is succeeded by the treeless grassy veld.

Southern Deserts and Semi-Deserts. In the west, as the distance from the south-east trade increases, the rainfall becomes more scanty and uncertain; the grass-land becomes poorer and poorer, and gradually passes into a broad semi-desert, the Kalahari, with scanty patches of grass and thorny bushes. Westward it assumes a typical desert appearance, and joins the Namib desert across the Damara-Nama plateau. Beyond the High Veld in the south are two long mountain-bordered terraces, the Karroos, which receive little rain and grow thirsty scrubs and bulbous plants.

All these countries are pastoral rather than agricultural. Until recently they were well stocked with game and formed a paradise for the hunter. They suited nomadic rather than settled life.

The South. The extreme south of Africa lies in the belt of westerly winter storms, and has the benefit of winter rains along its southern shores, which accordingly possess a mediterranean type of vegetation.

The South-east. Thanks to the trade winds, the south-eastern margin of South Africa enjoys summer rains and a comparatively luxuriant vegetation. Natal rises in successive terraces from the sea and has, at least in the lower ones, a semi-tropical character; but, perhaps on account of the wind, it is not forested to any large extent. Like the coastal plains farther north, the vegetation consists of tropical, deciduous, light woods and scrubs. On the middle and upper terraces there is a grass-land to the south, and a park savana to the north—a spur of the Zambezian savana.

The Eastern Coast and Tableland. Towards the equator the vegetation is more varied. There are (*a*) fringes of swampy mangrove along the sea and the main rivers; (*b*) tracts of hot wet forest on the lower

eastern slopes of the mountains and in other moist situations; (*c*) lighter tropical woodlands, savanas, and drier tropical scrubs. North of the equator the climate is drier and North-east Africa is an arid region of grasslands in the south-west and poor scattered acacia scrubland towards the east and north. The high equatorial plateau east of the western rift is mostly covered by a high savana and thorn-woodland, except for the marshy fringes of the Victoria and other lakes.

Abyssinia rises out of a drier land. It is a very much dissected tableland, with heavy summer rains and a cool climate on the top. It is covered mainly with pastures and scrublands. The loftier mountains and some of the valleys possess noble forests.

Madagascar, an outlying fragment of the African tableland, falls by a steep escarpment to the Indian Ocean on the east, while it sinks by a succession of terraces to sea-level on the west. The uppermost plateau is covered with savana, while the eastern slopes, which receive very heavy rains, have dense forests of the equatorial type. On the western terraces there spreads a variety of lighter tropical woodlands, savanas, scrubs, and the south-west, which receives the minimum of rain, is even semi-desert.

CHAPTER XXXIII

AUSTRALIA AND PACIFIC ISLANDS

Australia may be regarded as a tropical desert surrounded by a fertile margin. From all sides sea winds blow in at one season or another towards the interior of the continent. Their moisture is precipitated on the

more or less interrupted belt of higher land which encircles it. Accordingly we find a roughly concentric arrangement of the vegetation: a belt of woodland, a belt of savana, a belt of scrub, and the desert succeed

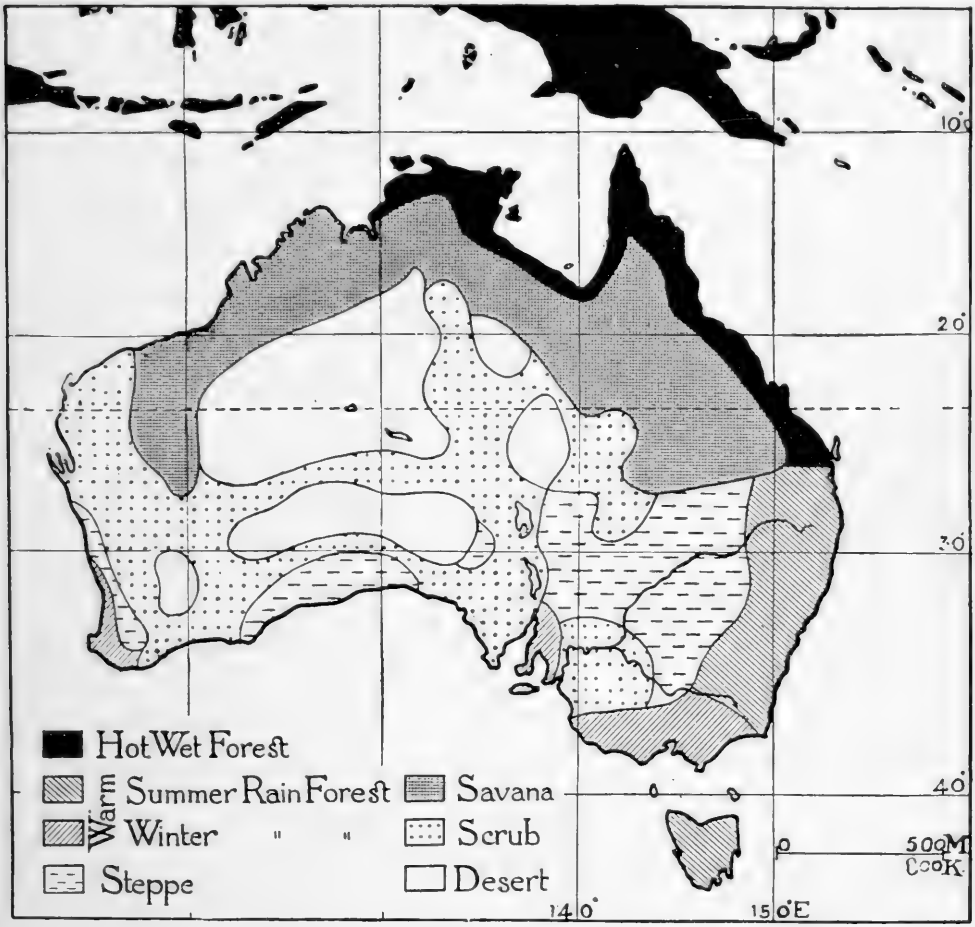

Fig. 65. Vegetation of Australia.

each other from the coast to the interior. There are, however, many variations of this general plan.

Northern Australia. The northern coast receives the benefit of a strong summer monsoon, which varies in strength from year to year. In the absence of any high

mountain range the precipitation over the coastal belt is not so large as it might otherwise be. As this region lies well within the tropics, the landscape is one of light tropical woods of the drier monsoon type, frequently broken by grassy glades. The vegetation is, on the whole, deciduous. The hot wet equatorial type of forest is found only in tracts with sufficient ground water. Mangroves fringe the coast here and there.

The North-East. In the north-east, especially on the eastern slopes of the Eastern Highlands, the amount and continuity of rainfall are sufficient for a dense forest resembling the great equatorial selva. This is found only here and there in patches.

The Eastern Highlands. From the tropic of Capricorn southwards the forests that clothe the seaward slopes of the Eastern Highlands are of the luxuriant moist type of warm temperate countries, with tall eucalyptus as the dominant feature. On the western slopes the climate is much drier, and the vegetation is chiefly remarkable for its thin forests of shadeless, bark-shedding eucalyptus, with a grassy undergrowth. Farther inland, at lower elevations, these light woods are broken by still drier scrubs studded with clumps of acacias and other trees, and by grassy glades of savana, stretching on to the grassy belt that encircles the arid interior.

The South. Both southern extensions of Australia lie within the belt of westerly storms in winter, more so than the southern fringe of South Africa. They therefore have a mediterranean type of evergreen vegetation. This is especially the case in the south-west, where all mediterranean produce can be successfully grown, and vine, orange, olive, and other fruits are now cultivated. The northward incurving coast of the Great Australian

Bight is less fortunate in this respect, on account of its more northerly position. Its grassy savanas are now cultivated, and hard varieties of wheat are doing well. The belt of mediterranean vegetation which it interrupts is continued in the east along the slopes of the Highlands of Victoria.

The Scrublands. Apart from the park-like savana with its fringes of tall eucalyptus along the rivers, one of the most striking features of the vegetation of the interior of Australia is the dreaded scrub—boundless solitudes of evergreen, small and thick-leaved, sticky, dull green bushes, waterless and trackless, which form a broken belt round the grass-lands. Different varieties of it are known as the Mallee, Brigalow, and Mulga scrubs and heaths. The Mulga is the poorest and most open type, consisting of scattered shrubs and tufts of wiry grass and saltbushes, not unlike the alfa steppes of North Africa. It is found around and mixed with the sandy deserts, penetrating far into the interior of the continent, especially along the eastern margin of the Western Tableland.

The desert itself is principally found on the Western Tableland, with smaller tracts in the Central Lowlands. It is very similar to the Sahara, but without the charm of its oases. The camel has been introduced as the only means of crossing it.

New Guinea. The southern lowlands of New Guinea have similar vegetation to that of north-east Australia, but owing to the greater rainfall it is more luxuriant. Here is found a mixture of every variety of forest of the monsoon type, and in places, of the dense equatorial selvas and swampy forests. The northern part, separated from the southern by a lofty mountain barrier, and much more rainy and hilly, is clad, as far as we know,

with luxuriant and continuous equatorial rain-forests and wooded bogs. The long mountain ranges which run along the axis of the island have a succession of equatorial and moist temperate rain-forests.

New Zealand. The North Island, with an equable, mild, and rainy climate, supports a heavy and valuable rain-forest of the warm temperate type. The South Island is more diversified. The western slopes of the New Zealand Alps receive much rain from the westerly winds, and are heavily clad with temperate rain-forests of antarctic beech. The drier eastern slopes and plains are covered with grass and woods, not unlike the mediterranean type.

Pacific Islands. The countless islands of Oceania have this in common: that they lie in the inter-tropical belt, enjoy a warm and wet equable oceanic climate without drought or cold. They are spots of equatorial selva, generally of a lighter type.

Austral Islands. The few islands of the Austral Ocean are in a zone of constant rains and gales and of cool equable climate. All of them treeless. They have good grassy pastures.

CHAPTER XXXIV

ASIA

Comparing Asia with North America, the same succession of vegetation from arctic tundra to equatorial rain-forest is apparent, as well as a similar distribution of inland deserts and moister coastal tracts.

The Tundra. The southern limits of the arctic tundra lie farther north in Asia than in America. The moister mossy tundra seems to be more abundant than the lichen type which prevails in the Barren Grounds of Canada.

The Taïga. South of the tundra lies the most extensive coniferous forest of the World, one of its undeveloped assets. This, the Siberian taïga, stretches almost continuously from the North Sea across the Urals, the

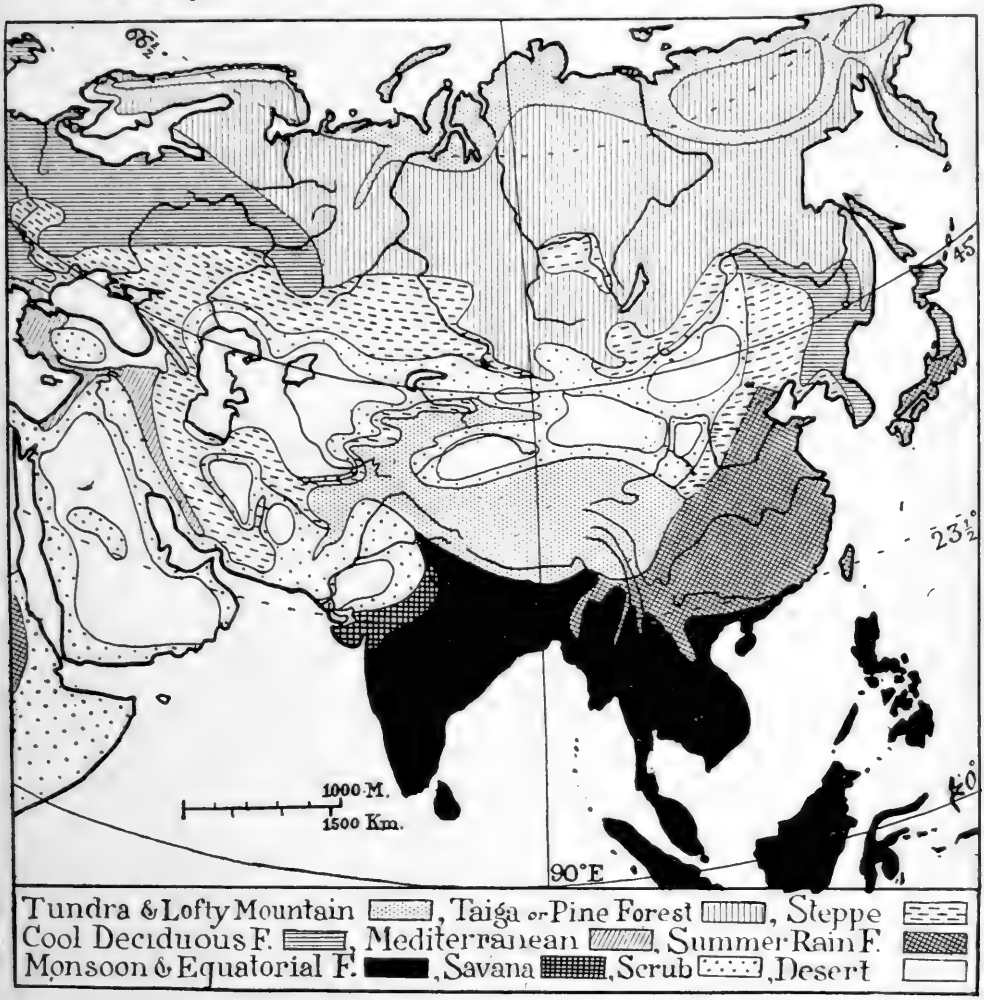

Fig. 66. Vegetation of Asia.

lowlands of Northern Asia to Kamchatka. Western Siberia, however, is an exception, for it is very flat and badly drained, and is covered with morasses and marshy forests. The taïga is not yet inhabited, and has hardly been opened up except on its southern margin.

The Steppes. Fringing the taiga on the south, at about 55° N., is a belt of park steppe, mainly composed of grass-lands with clumps of birch of various sizes. It forms a transition to the Asiatic steppe, and is a valuable belt both for prosperous farming and easy routes.

Deserts and Scrublands. Next comes the vast arid belt that stretches across Asia from the Mediterranean almost to Amuria, covering lowlands, terraces, and huge mountain ranges alike. The great deserts of Asia differ from the Sahara in having greater extremes of temperature, both daily and seasonal, while excessively hard winters are added to the horrors of the hot summer desert.

Around the desert belt vegetation is, roughly speaking, arranged in parallel bands. The steppe is the outermost one. Between it and the desert is a loose brush of low, stunted, dry evergreen bushes and dead grass, which passes gradually into a low, scattered heath of bare or small-leaved and woody shrubs like tamarix, saxaul, and calligonum, and on salt soils, a threadbare carpet of thick-leaved saltbushes. Beyond this is the desert where even these outposts of vegetation disappear before the shifting sand dunes among which the snow-fed rivers vanish.

Turan and its Borders. The Karakum (Black Desert) and Kysylkum (Red Desert) of Turan are the westernmost deserts. They are bordered on the north by the great Kirghiz steppe which succeeds the birch-steppe, and are prolonged westward to the Caspian across the Usturt plateau. In the middle of Turan lies the Aral Sea, into which the two mighty rivers, the Amu- (Oxus) and Syr-(Jaxartes) Daryas, fed by the snows of the Pamirs and the Tian Shan, empty themselves. Along the banks of these streams the water makes the ground fertile and spreads a chain of oases. Man will soon reclaim wider belts along these rivers by irrigation, and transform them

into new Egypts. Bordering the desert, along the northwestern foot of the high mountain wall and penetrating far into its recesses by the valleys of the Chu, Syr, Zerafshan, and Amu, a belt of foot-hills and terraces is fertilized by the waters from the mountains. Tree growth is here mostly confined to the riverside (though orchards are not uncommon), and the vegetation resembles that of the steppe. Irrigation makes cultivation possible.

The western part of the Tian Shan and Alai ranges, as well as the chains of Khorassan, condense the moisture of the northerly winds and are on the whole fairly well provided with water, especially in winter and spring. They have the same series of zones of vegetation: cultivation on the foot-hills, rich grassy pastures farther up, then a belt of conifers, followed by alpine or summer pastures below the bare ridges. Between the summer pastures and the winter meadows the herds and herdsmen move up and down with the seasons.

Iran and its Borders. The high plateau of Iran, screened by the higher rims of Elburz and Khorassan from the north winds, is swept by dry icy gales and exposed to great extremes of temperature. There the high treeless steppe of short grass surrounds arid depressions or salt-pans with the usual carpet of low, fleshy salt-bushes and heaths of tamarixes. This is especially the case in Khorasan and Kuhistan. The broad plain of Ispahan more closely resembles an alpine pasture, and where it is watered it has rich meadows. The oases have magnificent gardens sheltered by high walls. The mountain ranges which cross the plateau, like those of its margins, contain fertile valleys with good pastures and are more thickly peopled than the open plain. Eastern Iran resembles Turan in its deserts and salt tracts surrounded by meagre steppes and

scattered brushes along the foot of the outspurs of the Hindu Kush, with oases along the rivers. The valleys that diverge west and south from the Hindu Kush are centres of agriculture and population, and owe their relative fertility entirely to the snow-fed rivers.

The southern wall of Iran extends continuously from Armenia through the Zagros chain to India, and is formed of a succession of cliffs and terraces. Amid the wilderness of bare craggy ridges and precipices, however, a number of terraces and moist valleys shelter secluded little oases of gardens, fields, and orchards, and even low evergreen forests of a mediterranean type. The southern parapet of Iran rises above a narrow fringe of sun-baked desert, studded with palm oases.

The Tarim Basin, Zungaria, and Mongolia and their Mountain Borders. The plateaus extending from the Pamirs to the Khingans are enclosed on all sides by high mountain barriers and shut off from rain-bearing winds. Their relatively high latitude and the absence of moisture render them extremely hot in summer and extremely cold in winter. The chief plantless centres are found in the Tarim basin and in the Western Gobi. The Tarim basin is mainly covered by the Takla Makan desert, a sea of shifting dunes. The narrow margin between it and the mountains is occupied by concentric girdles of heath-like brushes, marshes, and coarse winter pastures, of oases on alluvial fans, of gravel wastes, and cultivated terraces, above which, on the mountain slopes, summer pastures extend. A similar arrangement is found on a larger scale in the Gobi or Shamo desert. North of the Shamo there is a zone of meagre sage-brush and short scattered grass. A line of marshes and lakes joins the points where the converging mountain streams lose themselves in the desert; a belt of steppe skirts the base of the foot-hills, and mountain pastures follow on the slopes. Between the

Altyn Tag and the Kwenlun systems the higher terrace of the Zaidam, with its great swamps and deserts, has a yet bleaker, colder, and drier landscape. Tall poplars replace palms in the oases of Central Asia.

Of the mountains that bound the vast Asiatic plateaus on the north, west, and east, the outward slopes are generally wooded, but the inward slopes are less so or are treeless. The portions of those ranges which, like the Altai, Tarbagatai, and Tian Shan, extend far into the deserts, are devoid of forests, and their alpine pastures are gradually restricted to higher and higher elevations.

The Pamirs. On the Pamir plateau the mountain ranges are compressed into a narrow belt of lofty ridges and high flat valleys. This is the Karadagh, the roof of the Old World. Buried in snow for several months of the year, these valleys possess good summer pastures of an alpine type which are utilized by the Kirghiz herdsmen.

Tibet. Farther east the ranges spread out, the high valleys broaden, and the Pamir plateau expands into Tibet, which is made up of wide, level, west-east valleys between mighty parallel ridges. Lying at elevations of from 12,000 to 16,000 feet, subject to excessive alternations of heat and cold, swept by icy gales at all seasons and snow storms in winter, the high flats can support in some places only a loose, short sward of alpine grasses and perennials on which herds of sheep and yaks feed. The eastern part of Southern Tibet enjoys a somewhat milder climate, and agriculture and even orchards are found in its broad valleys and plains. The population is almost restricted to this region.

The eastern slopes of Tibet are carved into narrow and deep gorges between steep parallel ridges. They receive rain from the summer monsoons of China, which are carried far into the plateau. The vegetation is luxuriant.

On this side prosperous alpine pastures are found far into Tibet. Below them, a belt of conifers reaches down to dense deciduous broad-leaved forests, and these again to warm temperate, rain-forests, the beauty, wealth, and luxuriance of which have been the marvel of travellers.

Eastern Monsoon Lands. East of the great system of Siberian, Mongolian, and Tibetan plateaus, the broad marginal belt is entirely open to the summer monsoon rains; but differences in temperature as well as in rainfall permit a great variety of vegetation.

Amuria. The hilly region of Amuria has a climate similar to that of Central Europe, but with much greater extremes of heat and cold. It possesses a rich park-landscape of broad-leaved deciduous and of coniferous forests and excellent meadow-land, not unlike our own. It is capable of great development. South of it, shut in on all sides by mountain ranges, lies the rolling land of Manchuria, a dry, treeless steppe, which is often called the eastern Gobi. Only the ranges east of the Sungari and the narrow coastal belt have heavy woods of our northern type.

China proper has been so long under the influence of an intensive agriculture, which has encroached high up on the mountain woodlands, that little of its spontaneous vegetation is left. The west-east range of the Tsinling Shan and the highlands north of the Yangtse seem to mark a natural division between two types of climate, vegetation, and agriculture. In the north the country suffers from the marked seasonal changes of temperature and the dry as well as severe winters. Both the vegetation and agriculture have a northern, summer-green character, similar in many respects to those of the centre of North America. The chief crops are barley, millet, wheat, maize, cotton, tobacco, and hemp. The soil is the

rich yellow earth, which is immensely fertile, favours intensive cultivation, and supports a dense population. The southern slopes of the Tsinling Shan are partly clad with rich forests. They show a decided change from the northern conditions and have an ever moist, warm temperate climate, corresponding to that of the south-eastern region of North America. The whole valley of the Yangtse, as well as the lower zone of forests in the Sechwan and Hupei highlands, have the same generous climate. Rice, tea, and cotton flourish under the best conditions. The immense variety of crops, and the patient, thrifty, strenuous industry of the natives make the Yangtse basin one of the richest agricultural countries in the World, while the forests are exceedingly valuable for their economic products.

Japan. These mountainous islands, in a mild and moist climate with no long period of drought, may be divided into zones of altitude, ranging from the sub-tropical, evergreen rain-forest to the snow-line. Conifers play an important part in the landscape; a belt of low hills and woods of black and red pines lie behind the fringe of coastal dunes. Cedar and cypress characterize the next forest zone. Above 3,000 feet larch and fir recall our northern coniferous forests, while after a girdle of dwarf pines, alpine pastures extend above 6,000 feet. In the northern half of Honshiu (Hondo) and the chain of islands to the north the lower zone is of the cool, temperate type. Formosa is tropical.

The Southern Monsoon Lands. In the belt comprising India, Indo-China, and the Malay Archipelago, we find a repetition of the conditions of tropical America.

The Malay Archipelago is equatorial in character; but whereas the southern and eastern slopes and plains exposed to constant downpours are mostly clad with the

heavy, hot and wet, evergreen rain-forests or selvas, the northern and western slopes have dry seasons, and their vegetation varies accordingly from lighter deciduous forests, of which teak is the most valuable component, to wooded types of savanas. The higher zones of the mountains display a temperate, evergreen aspect in their rain-forests; but the wind reduces the vegetation of the summits to mere shrub- and grass-land.

Indo-China is strongly influenced by monsoons. Most of Siam and Cambodia is covered by a park landscape of light tropical woods of the teak type, savanas and jungles. The mountain land to the north and west is heavily forested, teak predominating in the lower zone, while the little known upper zones are covered with moist, warm, temperate rain-forests. Heavy equatorial selvas characterize the lowlands of Cochin China, but they have largely disappeared with clearing and cultivation. Much of the lowlands of Indo-China, formed by the enormous deposits of the great rivers, were reclaimed directly from swamps and transformed into rice-fields before they were occupied by forests. The Malay peninsula lying in the equatorial belt is still largely clad with hot wet forests.

The Himalayas. On the northern mountain barrier of India the lower zone of vegetation up to 5,000 feet is tropical. The western portion is relatively dry, the eastern quite wet. The north-eastern corner of India and the lower parts of its amphitheatre of mountains, as well as western Burma, lie under conditions which favour the heaviest type of equatorial selva. The well-timbered temperate zone of the Himalayas, including wet evergreens and, higher up, deciduous woods of northern aspect, stops at about 11,000 feet, and is followed by treeless alpine pastures rising to 18,000 feet.

The Indo-Gangetic Plain. The alluvial Indo-Gangetic lowland is of the hot and wet description in the east, but it gradually passes westward through all stages to extreme aridity in the Thar Desert.

The Indus plain properly belongs to the system of subtropical deserts which includes Arabia and Mesopotamia. It is an arid land with a low vegetation of dry herbs, dotted with acacias and other leaf-shedding shrubs. It depends entirely for its water on the snow-fed rivers from the Himalayas, and its cultivated tracts are all in the nature of oases.

On the other hand, the Gangetic valley, which receives the monsoon rains and many large Himalayan rivers, is by the help of an abundant irrigation transformed into a rich agricultural land where rice, cotton, indigo, and opium yield heavy crops.

The Deccan and Ceylon. The Deccan plateau has wet margins but a drier interior. It receives heavy monsoon rains from the south-west on its western escarpment. The narrow strip of Malabar, together with the south of Ceylon, possess an almost impassable barrier of dense selvas. The eastern lowlands of the Coromandel coast and northern Ceylon receive much less rain and have a jungle vegetation of dry evergreen scrubs on hot sands. The plateau itself, according to the dryness of the climate and nature of the soil, consists of arid centres, grassy expanses, vast areas of dry deciduous shrublands, light deciduous woodlands, and teak forests.

Burma. Eastern and Lower Burma are well known for their deciduous teak forests. The mountainous highlands in the rear, little known as yet, are heavily clad with warm temperate rain-forests of the tea-camellia-camphor type.

CHAPTER XXXV

EUROPE

The Tundra. Both on account of the lower latitude of the northern shore of Europe and of its moderate temperature as compared with that of Northern Asia, the tree line is carried almost to the very margin of the Arctic Ocean and the tundra comprises but a narrow fringe of the mainland and the Arctic islands. The arctic-alpine vegetation of pastures and marshes, however, is carried far south into Scandinavia on the fjelds of the Scandinavian highlands. On these barrens a scattered population of Finns and Lapps roams after its half-wild herds of reindeer, on which it largely depends. These nomads fish and hunt, and in favourable years reap a poor crop of oats or rye on the margins of the forest.

The Taïga. The Siberian taïga extends westwards across the Urals and covers the northern half of Russia and Scandinavia, north of 63° N. It is fringed on the north as well as on the slopes of the highlands by a narrow strip of birch woodland. The Scottish Highlands, and a narrow coastal fringe in southern Iceland, might be considered as outliers of this belt. Timber felling and its attendant industries of carpentry, match and wood-pulp making, tar and wood distilling, along with fur-hunting and fishing, and a very little agriculture, are the chief occupations amid these forests. With such limited possibilities, due to unfavourable soil and climate, the northern populations hardly find enough to live on in any one place, and many resort to seasonal migrations. Northern

Russia lacks facilities of transport for the marketing of its timber. Finland and Scandinavia carry on an extensive timber trade, chiefly by water-floating, and in the preservation of their natural resources they have developed a high skill in forestry. These hardy races have also succeeded in evolving a science of northern agriculture which makes the most of very poor circumstances.

Cool Temperate Forests. The cool temperate belt includes the southern half of Scandinavia, most of Britain, northern and western Spain, and the rest of Western and Central Europe. Towards the east this belt narrows between the taïga on the north and the steppe on the south to a point in the vicinity of the southern Urals. Its characteristic vegetation is a park landscape of deciduous, broad-leaved woods and meadowland : most of it, however, has been deforested. Oak, beech, maple, elm, ash, poplar, and thornbeam are the chief trees. Within this belt great varieties of landscape are found, owing to differences in topography, soil, and climate. From west to east the climate gradually becomes more extreme, with harder winters and drier, hotter summers.

The west coast belt, comprising the south-west of Ireland and England, a narrow fringe of France, and the northern and western slopes of Spain, is always wet, cloudy, and mild. The luxuriance of the vegetation is greater than farther inland. These regions are mostly transformed into rich pasture lands.

The Central European plain, starting from Flanders, consists of lowlands covered with heather moors, peat bogs, pine and birch woodlands, and sandy pastures. It passes in the east to a bleak region of forests and marshes and ends in Russia in the vast Rokitno swamp, the marshlands of the Minsk and the Pripet.

The Central Highlands and Karpathians. More or less isolated masses of highland, such as the central plateau of France, the Vosges, the Schwarzwald, the Lower Rhine highlands, the Thüringer Wald, the Harz, and the highlands bordering Bohemia, rise above the deciduous forests into pine- and pasture-clad slopes, often with peat moors on their tops. The Karpathians are well stocked with stately forests of conifers and possess alpine pastures. They are decidedly moister on the northern than on the southern slopes, in the west than in the east. The Karpathians are separated only by a narrow lowland gate from the Alps, which resemble them in point of vegetation.

The Alps. Three main zones may be distinguished in the Alps, (*a*) the deciduous, broad-leaved forests of oak and beech, (*b*) the coniferous forests of firs, pines, larches, and arves, forming the sub-alpine zone, while above a fringe of scattered woods and shrubland rise (*c*) the alpine meadows and marshes, followed higher up by lichen-covered tracts under the snow-line. On the western and southern slopes of the Alps a lower belt of evergreen oak woodland is usually found in addition.

The Steppes. In the south of Russia the steppe climate, with its corresponding vegetation, succeeds to the deciduous forest belt. The transition is almost abrupt in places, but generally is made by a gradual thinning of the forest followed by a fringe of islands of hornbeam-trees. The steppe stretches from Rumania and Bulgaria to the lower Volga, and joins the Asiatic steppe. Under proper irrigation the *chernoziom* or black earth of southern Russia which extends to the foot of the Caucasus is exceedingly fertile. The northern margins of the Black Sea are poorer and pastoral, except for the isolated hilly tract of Crimea, which is a western outlier of fertile Georgia.

The Caspian Semi-Desert. In the south-east, towards the Caspian, the dryness of the climate increases, and the steppe becoming poorer and more ragged passes into a semi-desert of wormwood.

The Western Islands of Steppe. The steppe extends westwards to the foot of the Karpathians. There is an outlier in the Hungarian lowland, encircled by mountain ranges. The climate of Hungary, dry and extreme in temperature, is hostile to forest growth and favourable to a pasture-land in the nature of a steppe, though more luxuriant, called the Puszta, famous for its horses. By means of irrigation, which is easily carried out, a large portion of the plain is cultivated for wheat. The sunny and warm slopes of the hills are extremely favourable to the vine.

Farther west again, similar conditions in a somewhat milder form are found in the lowlands of the Po. These are carefully irrigated and intensively cultivated. The plain of the Po owes its fertility to its rivers.

Spain also offers a few low rainless centres, but only the Ebro steppe has the northern type—the others are rather African in character.

The Mediterranean. This region of dry hot summers and mild, moist winters includes the north-western corner of Africa and the coastland of Syria and Asia Minor. It extends across the southern part of the Balkan peninsula. Its vegetation is characterized by thick, leathery, small-leaved evergreen trees and shrubs in woodlands, scrubs, and jungles, with but little pasture-land. The zones in the mountains are those of (*a*) evergreen oak, (*b*) deciduous oak, (*c*) beech, (*d*) conifers, and (*e*) pastures or rock barrens. Its natural resources are many: olives, evergreen and cork oaks, vines, figs, and carobs are among the most common and characteristic. The scrubs,

whether the rocky, loose garrigue or the denser and taller maquis, have replaced the original woodlands.

The varied appearances of the landscapes of this region cannot be dealt with here.

The south and eastern coasts of the Black Sea receive an abundant rainfall, and enjoy a generous climate, which is revealed in a luxuriant vegetation of dense forests, similar to those of south-eastern North America. Towering above this rich coast is the chain of the Caucasus which condenses a large amount of moisture, and has stately forests and tall luscious pastures. Here lies the rich and rainy forest-land of Transcaucasia, which leads to the north-west corner of Persia, and is continued south of the Caspian on the northern slopes of the Elburz Mountains.

Mediterranean conditions are found round the southern wall of the Anatolian plateau and extend along the mountains to the intermontane valleys of south-west Persia, rising above Mesopotamia. The Anatolian plateau is a high, treeless, half-desert steppe, studded with salt depressions, and thinly peopled.

Mesopotamia, mostly composed of alluvial land, is a vast oasis, owing its fertility to the water and the rich alluvial deposits of the two rivers. It is hemmed in between the wall of Iran and the Syrian plateau. The latter, with a mediterranean vegetation, which passes into desert as the plateau descends gradually to Mesopotamia. In Syria, however, the desert has lost its tropical climate, and its winters may be cold.

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